ELEMENTARY AGRICULTURAL AIR PHOTO INTERPRETATION

with particular reference to Eastern Canada

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Cover Photo

Air Photo Illustrating the Pattern of Land Tenure in the Vicinity of Bourg Royal, Quebec, July 5, 1950. This region was settled in the early days when the communal system of farming was common. The houses and barns were located in the center of the "hub" and were surrounded by a protective wall for defensive purposes. As Canada developed, and the protective wall became unnecessary, it was replaced by roads surrounding the central farm buildings. At a later date farm buildings were constructed outside of the fortress. The land was subdivided in a triangular fashion, with the apex of the triangle in the center of the fortress. Many of the farms were again subdivided by the early French families so that to-day there are many long farms with irregularly shaped fields.

ELEMENTARY AGRICULTURAL AIR PHOTO INTERPRETATION

Summary

1. Although air photos have been used extensively by agriculturalists in the past, all of their possible uses have not been exploited. There is, therefore, reason to believe that considerable expansion in their use will take place in the near future.

2. The authors outline a few principles of air photo interpretation, to assist beginners in their work. In order to become proficient in such a task, one must develop an inquiring mind and realize that it is essential that the interpreter have a working knowledge of farming practices in the area under study. A ground check is usually desirable and sometimes necessary to guide the interpreter.

3. As a general rule, the best results for crop identification, crop yields and general land use information may be obtained from vertical photos flown during the latter part of July. Information relating to soils, such as texture, drainage, erosion, etc., may best be obtained from vertical air photos flown during late May or early June when the land is relatively bare. General topographical and man-made features usually may be identified from photos flown at any time during the growing season.

4. If an intensive study is being made of land use in a given area, the uncontrolled mosaic provides an excellent base map.

5. The full potentialities of air photography can be realized only through the use of the stereoscope.

6. Most of the vertical air photos available, covering the agricultural areas of Eastern Canada, have a scale of one inch equals 1,320 feet with a 55 per cent forward and 30 per cent lateral overlap. These photos are ideally suited to the requirements of agriculture, insofar as interpretation is concerned.

7. Ground stereoscopic photographs serve as a useful guide to air photo interpretation. When a ground check is being made, such photographs may be taken to serve as a permanent record for future use.

8. General information: crop identification. Combinations of various tones establish definite patterns which become the key to identification by tone, thus:

    (a) The typical dark, almost black tone of alfalfa or clover is readily recognizable during May or June. Improved pasture generally has a medium gray tone and rough pasture a relatively light gray appearance during the major part of the summer.

    (b) It is not usually possible to differentiate between oats, barley, mixed grain or wheat, using standard photos and the lens-type of stereoscope. These crops may be recognized as "grain" at any time after the middle of June. Corn may be easily recognized any time after the middle of July. The characteristic white tones of buckwheat in bloom will identify this crop in the latter part of July.

(c) The regular pattern of orchard crops permits one to identify them at any time during the growing season. Vegetable crops and gardens can best be identified during the latter part of July.

9. Variations in soil texture may be observed rather clearly from a careful examination of air photos especially during the months of May or June. A good deal has been written about the identification of soils from air photos (See bibliography). The over-all color tone of soils is locally affected by the degree of wetness as well as the varying colors of the cover.

10. A general knowledge of the structure, weathering and eroding qualities of the underlying bedrocks and unconsolidated mantle is an essential aid to the identification of soils.

11. Silts and sandy clay soils generally have "U"-shaped gullies; granular materials have "V"-shaped gullies; very broad and shallow "V"-shaped gullies are usually found when the silty or fine sandy materials are over shallow bedrock or an impervious sub-soil.

12. The main types of projects for which agriculture has used air photos are as follows: soil surveys, land classification, irrigation projects, drainage and watershed control projects, crop acreage control programs, farm planning, farm appraisal, land settlement and development programs and the selection of sample farms for research projects.

Preface

This publication was prepared for the purpose of assisting those engaged in the study of agricultural land use to acquaint themselves with the elementary principles of air photo interpretation. It also provides a brief description of some of the uses being made of air photographs.

Most of the vertical air photographs included have a scale of 1,320 feet to the inch and in this respect are similar to photographs of Agricultural Canada in the National Air Photographic Library in Ottawa. Since a certain amount of detail was lost in reproduction the reader should not assess air photo interpretation on the basis of these photos alone.

The vegetative cover varies from month to month. Photos were taken, therefore, at three different times; namely, the end of May, June and July. When ordering photographs from the National Air Photographic Library, it is not always possible to obtain them for a given month. These photos are usually taken during the summer months (May to September) and one must therefore be prepared to interpret them for any period of time during these months.

The process of learning to interpret air photographs is largely a deductive one. Confidence may be gained from continuous investigation and enquiry, and a knowledge of the general farm organization of the area under study. The illustrations and the brief discussions presented here are intended to serve as a ready reference from which the reader may gain experience and develop a deductive process which will enable him to gain confidence and therefore greater accuracy in his work.

The air photographs included in this report are presented with the kind permission of the Royal Canadian Air Force. Recent air photos covering most of the agricultural areas of Canada may be obtained for a small fee from the National Air Photographic Library, Department of Mines and Technical Surveys, Ottawa.

Acknowledgment

The authors are pleased to acknowledge the most valuable suggestions and editorial corrections made by Dr. A. Leahy of the Field Husbandry Division of the Experimental Farms Service and Dr. J. D. Mollard of the Prairie Farm Rehabilitation Service of the Canada Department of Agriculture. They are also grateful for the generous assistance given by members of the Geological Survey of Canada Branch of the Department of Mines and Technical Surveys.

FIGURE 1.—*Map of Southern Ontario indicating the location of photographs included.*

PART I

General Uses of Air Photographs

Air photographic analysis is a recent scientific development. When properly handled it serves as a powerful tool in securing a great deal of the data needed in planning the use and development of natural resources. Greater use of this method in making economic surveys has been advocated from time to time in the past, but never before have conditions been so favorable for such an undertaking as they are now, especially because of extensive wartime experience with air photography and the greater supply of photographs available to the public. Many improvements in the air cameras and lenses, in plotting instruments and interpretational research have been developed and used both during and after World War II.

Air photography was first applied on a practical scale during World War I when it was used to detect camouflage, to locate enemy positions and to produce mosaics.[1] Since World War I it has been used in Great Britain and in North America for the preparation of topographical maps.

Canadian topographical survey, forestry and geological agencies have used air photographs since the early 1920's. The Topographical Surveys Branch of the Department of the Interior photographed an area at Pelican Lake, Saskatchewan in 1922 and quickly discovered that, by using air photos, vast areas could be mapped faster, more accurately and with less ground travel than was required by other methods of mapping. Timber estimates made in 1923 aroused extensive interest so that today the forestry interpreter is able to type trees, measure heights and give timber estimates from an interpretation of air photographs. The geologist has likewise extended his knowledge so that he is now able to designate on a photograph, particular geological features such as rock types, faults, folds, etc., and by limited ground checks he is able to further his interpretation, thus saving much time and travel.

Canada has several classical firsts in the field of air photography, such as the oblique plotting grid and the shadow system for calculating tree heights.

Today, however, air photographs have a more direct application to various types of land use surveys, in providing qualitative and quantitative information on natural resources and land utilization. For example, in the United States very large areas have been photographed by the Department of Agriculture for a wide variety of uses by its agencies. A few of the more important uses include: the production of planimetric and topographic maps for geological surveys; forest classification and inventory; land classification, land-use planning and range surveys; soil surveys; and field measurements for crop acreage adjustments by the Agricultural Adjustment Administration, for which air photography has been developed as the most economic and accurate method of checking performance under its farm programs. Similar developments have taken place in Canada and many European countries.

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[1]A mosaic is an air photo map formed by joining several overlapping vertical photographs. Uncontrolled mosaics are simply those in which the separate prints have been matched together as well as possible without correction, ground control or careful orientation. The controlled mosaic is elaborate and difficult to prepare since it is meant to present a very accurate map of the terrain. The uncontrolled mosaic is generally used for economic studies.

In Canada, technical personnel are using air photographs extensively to compile drainage and basin maps and as a valuable aid in geological and pedological identifications. They serve as a guide to identifying land that may be economically drained or irrigated, to identify old glacial channels, to locate landslide areas along river channels, to detect water seepage and alkali information, to locate construction materials such as sands, gravel and stone as well as to supply detailed information on relief and soil texture.

The possibilities of air photography are very great. Agricultural uses to which such photographs are being put include drainage and watershed projects, soil surveys, flood control projects, reservoir and dam site systems, and irrigation developments.

Most farm operators will find that vertical air photos serve as useful maps of their farms as they show the location of the various fields, lanes, water courses, details of the drainage systems and other information for farm records. Such photographs may be obtained for a fee of 50 cents per print by writing to the National Air Photographic Library, Department of Mines and Technical Surveys, Ottawa, stating the lot and concession numbers, township, county and province.

Air Photographs in Agricultural Economics

Air photos have been used extensively by agricultural economists in Canada. The first major undertaking in which air photos were used was the program of economic land classification in Western Canada which was carried on by the Economics Division of the Canada Department of Agriculture in co-operation with the Universities of Saskatchewan and Alberta. It was found that the photographs were of considerable assistance in the actual mapping of the areas under investigation. They made it possible to determine quickly and accurately the acreages of land used for different purposes. The photographs were used for office interpretation and greatly assisted in the preparation of an economic land classification map which was based on the data provided in soil and topographical maps and on economic information relating to the area. A somewhat similar use of air photos is being made in the development of an economic classification of land for Eastern Canada. In a recent study in Ontario, mosaics were used in the preparation of base maps, and stereoscopic pairs of photographs were used to supply more minute detail. Air photos have also been used to supply up-to-date information on the location of farmsteads for area sampling, to obtain details for individual farm planning or appraisal, to estimate flood damage and supply land-use information for proposed new areas of settlement.

Most specialists in the various fields of agricultural economics will find air photographs useful and those engaged in land-use planning will find them essential in their work. As a land economist is seldom a specialist in other fields, it is usually necessary for him to work with a soils specialist, geologist or a forester to obtain the best possible interpretation. One is able to study how certain characteristics of farms, ranches and forest cover vary in a geographic pattern from a mosaic.

Ground checks are necessary to interpret photos and field surveys must be conducted to secure economic data relating to an area. One may obtain a list of the location and size of farm units, plot them on a mosaic and interpret the variations in a geographic pattern. A type of economic land classification of the farms in an area may be made by plotting land use, soil types, land values, financial returns and other pertinent data on a mosaic of a given area. This procedure is not very different from earlier methods of making land utilization studies

in the eastern United States. It has the advantage, however, of reducing to a minimum the time-consuming and costly field work. This type of information is also useful in economic studies where inventories of the physical resources of a given area are required.

When settlement of a new area is proposed, an assessment of the present physical and future economic resources is usually considered necessary. Through the interpretation of air photographs, soil specialists may assess the quality of the soil and the acreage of land available for settlement. The economist may then appraise the soundness of a given project in terms of anticipated returns to settlers.

Air photographs are also used in the management and sale of properties acquired by counties at tax sales.[1] Members of the Veterans' Land Act Administration as well as other farm appraisers have found widespread use for air photos in their appraisal work.

Another use which has been made of the air photo is in the selection of a sample of farms. In many areas, maps of the required degree of precision are not available. In such cases it is possible, with the aid of air photos, to determine the number and location of farms, for sampling purposes.

There are numerous other situations where the economist, the agronomist and the soils specialist may use air photos to obtain information for land-use planning.

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[1] "We find that they aid greatly in determing values. In many instances more can be gotten, and better judgments formed, from an hour's study of an air photograph than from a day's inspection on the ground." Air Photographs. *Pennsylvania Planning* series, Vol. 9, No. 3. Harrisburg, Pennsylvania, Department of Commerce, State Planning Board. 1944. p. 10.

FIGURE 2.—*Illustrating the equipment used for taking and interpreting vertical and ground stereoscopic photographs.*

A. Aerial photo camera and equipment installed in aircraft.
B. The common Kodak camera with stereoscopic attachment.
C. Folding lens type, pocket stereoscope in position for use.

FIGURE 3.—*Vertical air photo, photographed May 30, 1952, illustrating some general features of farm land in the vicinity of Lake Constance, Ontario, with stereopairs of insert areas.*

The Stereoscope

The object of the stereoscope is to obtain a three-dimensional picture of the object viewed. This requires that the conditions for natural depth perception be artificially reconstructed and necessitates the following: (1) two slightly different views of the same object or scene from different angles; (2) correct orientation of the two views with respect to one another and to the eyes; and (3) normal binocular vision, allowing the two images to be recombined in the brain so as to give the effect of a single picture.

Ground stereoscopic photography is comparatively well known and has been practised for years. The method commonly employed is to make two simultaneous exposures on different sections of the same film strip, using a special camera or the common type of camera with a special attachment (Figure 2) having two lenses, separated by a distance about equal to that between the average person's eyes.

In aerial stereoscopic photography the principle is the same but the practice is somewhat different. Only one camera is used (Figure 2) and the exposures are simply made at regular intervals with the camera in a fixed position pointing in a direction perpendicular to the line of flight. The distance between exposures is such as to permit the photos to overlap in area. Any overlapping vertical photographs made with the same camera from the same altitude, when correctly oriented, permit stereoscopic observation of their common area.

There are three ways by which stereoscopic photographs may be viewed: by means of a stereoscope; by using superimposed images in complementary colors, red (primary) and blue-green (secondary); or by using superimposed images with polarized light. The first method is used entirely throughout this publication.

There are two main types of stereoscopes: the refraction or lens type (Figure 2) and the reflecting or mirror type. The mirror type enables the viewer to obtain the entire stereoscopic area of the two photographs. The lens type (Figure 2) is limited by prismatic qualities of the lenses and the stereoscopic area is small by comparison with the mirror type. The lens type has magnifying qualities whereas the mirror stereo has a diminishing effect. One supplements the other, but if a choice had to be made, the writers would choose the lens type.

Throughout this publication the orientation of the photographs for viewing under the stereoscope is fixed. The corresponding object distance is approximately two and one half inches. This means that the viewer simply places the left lens over an object in the left photo and the right lens over the same object in the right photo. The stereo is then rotated very slowly in either direction to eliminate blurring, thus focusing to obtain the stereoscopic or third dimensional view. Normally the viewer has to orient the loose photographs. One would begin by establishing his approximate eye base distance (usually about $2\frac{1}{2}$ inches), adjusting the stereoscope until the center of each lens is the same distance as the eye base, and then orienting each photograph so that each lens is directly over the corresponding objects in the photographs. Stereoscopic photographs can only be viewed correctly if the photographs are laid out according to the direction of the flight of the aircraft. If the photographs are reversed, the stereoscopic view is reversed (river beds become ridges, ridges become valleys, etc.).

Air Photo Interpretation

A great deal can be learned from a detailed study of aerial photographs that escapes the attention of the casual observer. It is only through the use of a stereoscope that the full

potentialities of aerial photographs can be realized. The identification of features requires a certain amount of practice and it is well if the novice can actually compare the photographs with features on the ground. By so doing he can soon learn to recognize natural and man-made features represented on the photographs. He can also learn the limitations of any type and scale of photography for a given purpose.

TONE.—By studying the elements of photographic record, one is able to understand how it is possible to build up a picture of conditions on the ground. For example, it will be noted (Figure 3) that the tones or shades vary from black (a) through a series of grays (b, c) to white. Combinations of the individual tones establish definite patterns which become the key to identification by tone.

PATTERN.—Orchards or plantations of trees, for example, can be distinguished from natural forest land by the regular spacing of trees. Various types of land-use and field patterns are also easily recognized. Streams may be identified by their meandering patterns and the vegetation commonly grown on them.

TEXTURE.—Texture may be illustrated by the relative size, density and arrangements of a group of similar objects on the ground. For example, note the difference between the homogeneous tone of a new seeding of hay (Figure 3) (d) and the medium tone of a field of hay seeded several years ago.(e)

SHADOW.—Shadow is the result of sunlight and therefore depends on the elevation of the sun at the time the photos were taken. It also depends on the irregularity of the ground surface both in the sense of topography of the ground surface and of individual objects such as trees (f) and crops (g) protruding far enough above their surroundings to catch the sunlight. An example of how shadow modifies the tones and texture may be illustrated by the sunlight side of a gently rounded hilltop which has all its tones lightened in contrast to the general darkening of the tone on the slope away from the sun even though there may be no difference in the nature of the cover. Shadows may disclose the shape and size of an object even though the object itself may be unrecognizable on the vertical photograph. The object's vertical dimensions, as shown by the shadow, may be more characteristic than the horizontal dimensions as shown by the image, or its tone may blend with the surrounding landscape while its shadow may stand out in contrast.

OUTLINE.—Outline will be generally irregular in the case of natural features and generally regular in the case of artificial man-made features such as roads, fences, tile drainage, etc.

RADIAL DISPLACEMENT.—Since the distance from the edge of the air photo to the camera is much greater than from the center of the photo, there is a distortion of the images on the outer edges known as radial displacement. The effect of radial displacement is easily seen in any air photograph of objects having considerable vertical dimension such as trees, buildings, etc. These appear to lean outwards from the center. The farther from the center and the taller the object, the greater is the leaning effect.

GENERAL PROPERTIES.—Before making use of a set of air photographs, full details should be obtained as to their properties—the elevation at which they were taken, date, negative scale, whether they are contact prints or enlargements of the original negatives and overlap. As the scale of the original photograph determines the limit of observable detail, it has an important bearing on the extent of interpretation possible. The percentage overlap is important in connection with the stereoscopic examination of photographs and planimetric control for the purpose of transferring pertinent data to base maps.

FIGURE 5.—*Vertical stereo of an area in the vicinity of Carp, Ontario, May 30, 1952.*

FIGURE 6.—*Vertical stereo of an area in the vicinity of Carp, Ontario, June 30, 1952.*

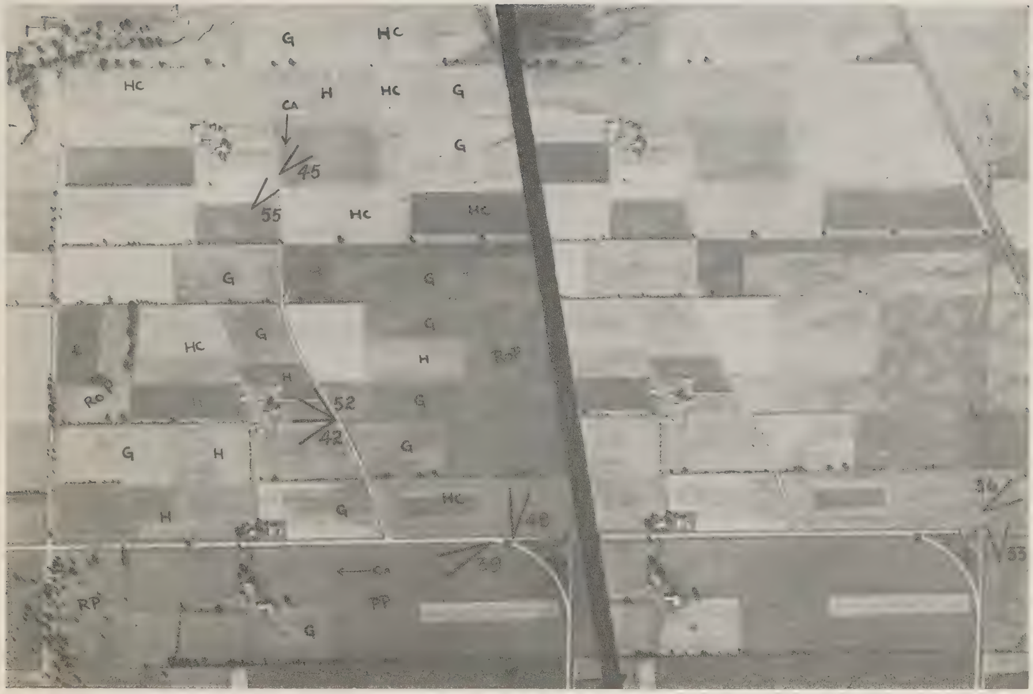

FIGURE 7.—*Vertical stereo of an area in the vicinity of Carp, Ontario, July 30, 1952.*

Man-made features generally contrast sharply with natural features. Owing to their ready identification and familiar character, they provide excellent subject matter for introductory practice in photo interpretation. Such items as main highways, country roads, rivers, railways, fences, hedges, trees and buildings appear rather obvious when viewed by a stereoscope (Figures 5, 6, 7). Notice the underground tile drainage (T) leading into a neighboring stream, the pattern of a recently manured field (MA), a farm lane (L), a roadside ditch (D), deciduous trees (DE), coniferous trees (CO), a small livestock watering hole (W), cattle (CA), and man-made drainage (DR). The cultivated fields are all rectangular in shape which indicates rather level topography, and free of obstructions. Since almost all of the land is under cultivation, one may suspect that it is a rather productive soil (in this case highly productive clay loam). The parallel drainage pattern indicates a rather gentle slope towards the river in the upper right of the photo. Notice that the drainage pattern may be much more clearly observed in May when the land is relatively bare. Such details as pastured livestock and the white line in the center of the highway may be observed in the original photograph but do not show up too well in reproductions.

Measurement.—Distances between two points may be easily measured on the photograph. There are various ways of obtaining the scale of the photos. The system used depends on the accuracy required. Township, concession or other ground surveyed plans, when available, or actual tape or chain measurements, made of any field, etc., will give sufficient accuracy. The use of flying and camera data, plus a reasonable estimation of the average ground height will afford measurements for general use. The larger scaled topographical maps, such as one mile to the inch, have been used and found sufficient for general measurements.

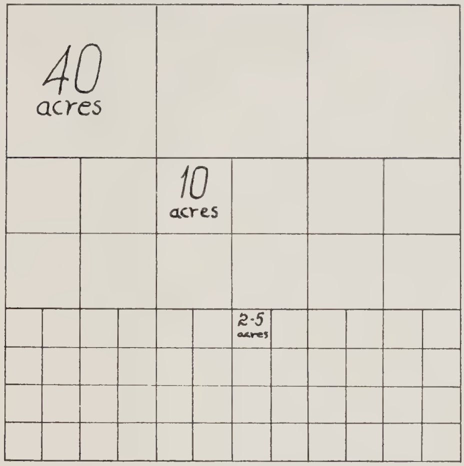

Figure 4.—*Scaled Grid, 1320′ = 1″*

Areas may be measured by constructing a scaled grid (Figure 4) on any transparent material and placing it over the area to be measured. Because of flying errors, topographical relief, and optical distortion, the scale on the photos is not constant. Different scaled grids can be easily constructed. These are generally sufficiently accurate for most of the work which the farmer, the appraiser or the agricultural specialist may be called on to do.

Most of the air photographs available, covering the agricultural areas of Eastern Canada, have a scale of 1,320 feet to the inch (or one inch equals 15,840 inches). These photos when printed on semi-matte, double-weight, unmasked paper are ideally suited to most of the requirements of agriculture insofar as interpretation and man-handling are concerned.

PART II

Crop and Soil Identification in Eastern Canada

General.—One of the main purposes of this project is to analyze the most common crops and some soils of Eastern Canada from an air photographic point of view. Since the vegetative cover varies greatly from month to month during the growing season a permanent record of how these local variations appear in an air photo would be invaluable to an air photo interpreter. Such a reference would reduce the amount of field work necessary to complete a project, and permit the uninitiated to become a reasonably competent air photo interpreter.

Although most of the photographs presented in this publication are illustrations of the St. Lawrence Lowland Region, they are intended to be sufficiently general to apply to most farming areas of Eastern Canada.

Method.—Because of seasonal variations in the vegetative cover of the farm lands of Ontario it was decided to obtain air photos covering the area selected for study at different periods of time. Most of the air photos relating to crop identification presented in this report were taken in three consecutive months, namely: May 30, June 30, and July 30, 1952. On these same dates, many ground stereoscopic photos were taken and are presented as an Appendix to illustrate the actual appearance of the various crops, soils, etc., on the ground at the time of flight. In this manner it will be possible for the uninitiated to visualize the exact object he will observe when viewing the air photo under a stereoscope.

Description of the Area.—The flight lines selected for photographing are located in eastern Ontario about 25 miles west of the city of Ottawa.[1] The illustrations presented are intended to cover the variety of the more common crops and some soils found in the mixed-farming areas of Eastern Canada. Climatic data for the Ottawa area during the growing season are presented in Table 1.

Table 1.—Long-Term Average Growing Season, Temperature and Rainfall Data, Ottawa, Ontario

	May	June	July	Aug.	Sept.	Oct.
Temperature, degrees F.	54.8	64.7	69.1	66.6	58.3	46.3
Rainfall, inches	3.50	3.51	3.17	2.37	3.13	2.87

The geology of this area is described in "Geology of the Ottawa—St. Lawrence Lowland, Ontario and Quebec"[2] as follows:

> "An immense interval of unrecorded time elapsed between the withdrawal of the latest Ordovician Sea and the beginning of the glacial period, for at present the irregularly eroded surface of the Ordovician and Pre-Cambrian rocks is overlain directly by unconsolidated Pleistocene deposits of glacial till and varved clays and by marine beds of clay and sand from the post-glacial Champlain Sea."

[1]A few photographs were selected from various areas of Western Ontario to illustrate several land forms not commonly found in the eastern part of the province (see Figure 1).

[2]Wilson, Alice E., *Geology of the Ottawa—St. Lawrence Lowland, Ontario and Quebec.* Geological Survey, Memoir 241, Canada Department of Resources and Development.

A working knowledge of the typical farm organization and practices is essential to the interpreter. Tables 2 and 3 illustrate the typical land-use program and the average kinds and numbers of livestock on farms in the Carp-Kinburn-Dunrobin area of Eastern Ontario (the area photographed). Cattle form the most important enterprise on these farms followed by hogs and poultry. Cultivated hay, pasture, oats and mixed grains are the most common crops produced on the typical farm.

TABLE 2.—Average Land Use, 766 Farms, Fitzroy, Huntley, March and Torbolton Townships, Carleton County, Ontario, 1951

Item	Average per farm
	acres
Oats	17.6
Mixed grains	10.2
Cultivated hay	32.4
Pasture	34.9
Other crops	8.8
Total improved	103.9
Woodland	35.3
Other	59.9
Total unimproved	95.2
Total, average per farm	199.1

TABLE 3.—Average Livestock Complement, 766 Farms, Fitzroy, Huntley, March and Torbolton Townships, Carleton County, Ontario, 1951

Livestock	Average per farm
Horses	2.2
All cattle	28.6
Sheep	4.2
Swine	8.8
Poultry	145.4

Arrangement of Photographs.—The vertical air photos appear in the main body of the bulletin. Several ground stereoscopic photos are presented in Appendix A to illustrate the actual appearance of specified crops on the ground at different periods of time. The scope of the ground photo is indicated on the air photo by a "V", with the picture being taken from the apex. One should concentrate on the air photos and use supplementary photos as a guide (see table of Illustrations).

Most of the photos presented in this section are in stereoscopic pairs. It is necessary, therefore, for the interpreter to use a stereoscope in order to obtain the best possible interpretation of the subject matter. Observation by means of the naked eye or a magnifying glass will not generally give sufficient detail for proper interpretation.

A list of the symbols used for the identification of crops is presented in Table 4. Other abbreviations are designated in the text or in the captions.

TABLE 4.—Symbols used for Crop Identification

Symbol	Crop
RP	Rough pasture
PP	Improved permanent pasture
RoP	Rotation pasture
MA	Manure or manured field
G	Grain (oats, barley and mixed grain)
C	Corn
H	Hay
H1	New seeding hay
Hc	Hay, cut
Gc	Grain, cut
ST	Straw pile
PL	Plowed land
TR	Trash

Crop Identification

HAY.—In general, a newly seeded hay crop photographs a rather dark gray because the luxuriant growth of clover and alfalfa almost completely covers the soil. New seedings of hay generally appear darker than any other cultivated crop. The foliage of clover and alfalfa absorbs the light and therefore appears to have this characteristic dark gray tone. After a year or two, much of the alfalfa and clover has died out, leaving a lighter cover of grass. Such grasses reflect light and since much of the soil may be observed, they appear to have a relatively uniform light gray tone when photographed from the air.

During the month of May a new seeding of hay appears to have a rather dark gray tone with the seeding pattern clearly visible the stubble, straw or the position of the previous year's stooked grain often may be observed in the photo. The seeding pattern is generally more difficult to observe during late June and a relatively uniform dark gray tone now predominates. Light gray blotches often may be observed as a result of imperfect drainage, of uneven seeding or of a concentration of straw from the previous year's grain crop.

In contrast to newly seeded hay, second-year hay has a relatively uniform dark gray tone with no evidence of a regular seeding pattern or stubble during the latter part of May and the month of June.

As a rule, hay seeded for three years or more in this area largely consists of timothy and other grasses and appears to have a light gray tone in the vertical photo with dark gray blotches in areas where alfalfa and clover have not died out. No evidence of livestock activity may be observed during the months of May or June. If such areas are pastured after harvest, it is generally not possible to differentiate them from improved pasture. Particularly weedy fields may appear mottled, especially if dandelions and other large weeds are in bloom. The older hay crops generally photograph a very light gray with a considerable amount of mottling caused by weeds.

Pasture.—Pasture may be invariably recognized in a vertical air photo by the presence of livestock and livestock markings in areas where livestock tend to assemble such as watering holes, near shade trees, or near the entrance to fields. Pastures generally have a light gray tone.

Rotation pasture during May usually has the appearance of being man-worked and a parallel "dead furrow" drainage pattern may be observed. Dark gray blotches appear in these fields because of the uneven grazing around weeds, stones and livestock droppings. The over-all pattern does not change greatly during June or July.

Rough pasture generally has the characteristic light gray tone of rotation pasture during the month of May but may be readily recognized by the generally rough topography, shallow soils, the absence of cultivation patterns and the blotchy effects of random tree growth, weeds, stumps, stones, paths, etc. Often such pastures exhibit considerable evidence of erosion. During June the tonal qualities of such pastures in an air photo do not usually change greatly. However, during July these pastures ordinarily have a very light gray appearance as they generally have dried up as a result of insufficient moisture, overgrazing or both.

During the month of May, improved permanent pasture, i.e., intensively pastured fields seeded with a special pasture mixture, is very similar in tonal qualities to a field of alfalfa and clover. Such fields generally have a relatively dark gray tone but may be readily differentiated by the following characteristics: They generally have the blotchy appearance of uneven grazing signs of livestock activity or the livestock themselves may be observed; and such pastures are generally located fairly close to the farm buildings. They retain the same over-all pattern during June and July but appear a lighter gray during the latter part of June and the month of July.

Grain.—Grain crops such as oats or barley may best be recognized in a vertical air photo during the latter part of June and the month of July. These crops are generally seeded in late May or early June and signs of growth are not too visible from the air for several weeks. Since most crops other than grain are already seeded and in an advanced state of growth at the end of May one may deduce, from typical cropping practices, that most of the land which is plowed, disked, or both, will be seeded to oats, barley, mixed grain, fall wheat, corn or buckwheat. The smooth surface of cultivated land is a good reflector of light and usually appears in a very light tone and is therefore readily recognizable.

At the end of June such crops as oats, barley, mixed grain or wheat are about 8 to 14 inches in height. The seeding pattern of the rowed grain may be easily observed as the foliage is not sufficient to cover the soil between the rows and the tone is generally lighter gray than a field of cultivated hay. Furrow ditches may be observed at regular intervals throughout these fields and there are no indications of livestock activity. The appearance of these grain crops at the end of July varies with their stage of maturity; ripened grain appears a very light gray

whereas the tone of immature grain is slightly darker. The seeding pattern may still be readily recognized. Often a field of grain does not mature evenly throughout, because of differences in drainage, and may appear to have streaks of very light to medium grays. It is not possible to identify whether the grain crop is oats, barley, mixed grain or fall wheat. A knowledge of the typical farm organization in the area may be of great value in estimating the approximate acreage in these crops, once the total acreage of all grains is known. Buckwheat may be recognized about the end of July by a uniform medium to light gray tone which is lighter than hay and slightly darker than fields of grain.

Ensilage corn or grain corn may not be recognized until the latter part of June when the grain is several inches high. The characteristic pattern of cultivated corn may be observed as there is a sharp contrast to the dark gray of the corn and the whitish gray tone of the cultivated soil. During the latter part of July, corn appears an almost black tone with the rows still visible and is, as a rule, darker than the surrounding fields. The relief of a corn field is higher than the surrounding fields of grain and hay during July and August.

Soil Identification

Introduction.—Most studies of agricultural land and its use are usually made of established areas that have been mapped by geological and soil survey personnel. Interpretations of these areas are less complex than are interpretations of areas that have not been so mapped.

A better insight into the interpretation of known areas can be had by acquiring a general knowledge of the structure, weathering and eroding qualities of the underlying bedrocks and geologic processes associated with the deposition of the glacial mantle.

FIGURE 8.—*Vertical stereo of an area in the vicinity of Kinburn, Ontario, May 30, 1952.*

FIGURE 9.—*Vertical stereo of an area in the vicinity of Kinburn, Ontario, June 30, 1952.*

FIGURE 10.—*Vertical stereo of an area in the vicinity of Kinburn, Ontario, July 30, 1952.*

Figures 8, 9 and 10 illustrate an area influenced by rock-knob topography. The enclosed areas in Figure 9 designate the actual pre-Cambrian granitic outcropping rocks. The white specks of the bare rock, the scrub and mixed forest growth, rough pasture and the abrupt topography, readily identify these areas. Figure 10 illustrates a small natural drainage system. Note the sub-parallel tributaries associated with the silt and clays to the right of the main gully and the parallel bedrock affected tributaries to the left. Other illustrations are: straightened drainage (D), strawpiles (ST), cattle (CA), spring (S), rock piles (RK), and a passage (ML), which has been mowed through a hay field, farm gardens (GA). These photos illustrate the change in tones during the months of May, June and July.

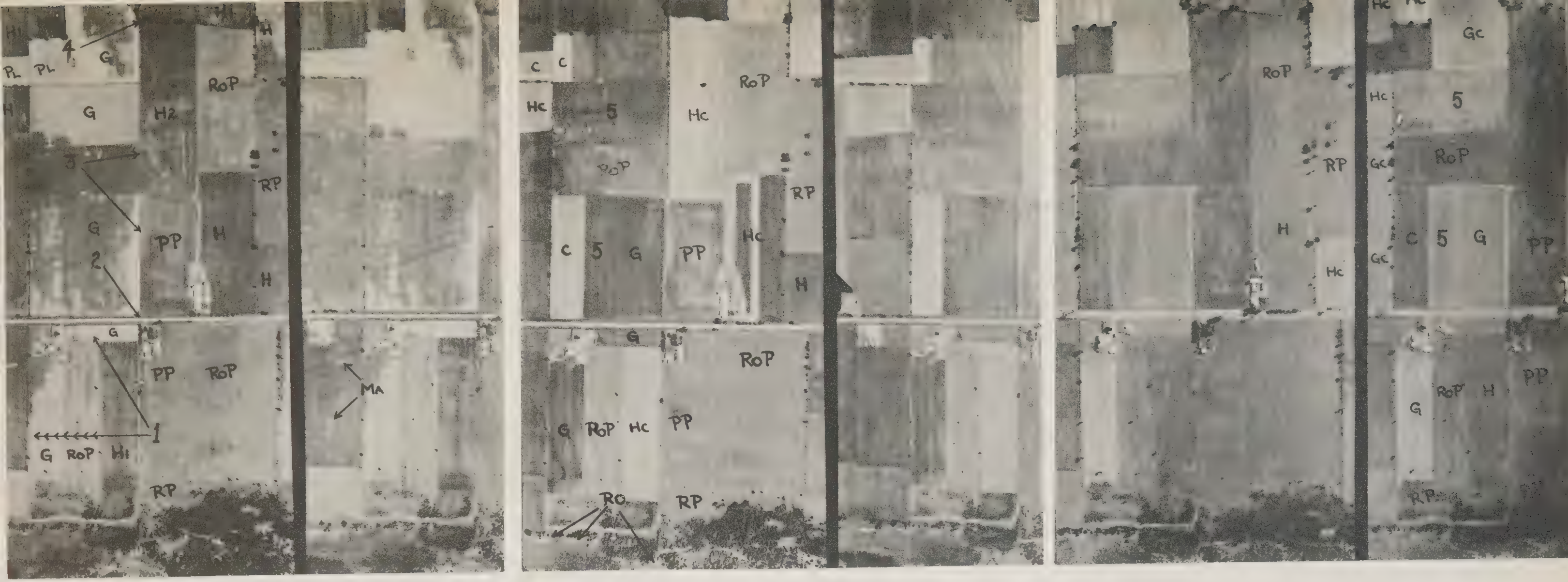

FIGURE 11. — *Vertical stereopairs, photographed May 30, June 30, July 30, respectively, illustrating typical clay loam soils in the vicinity of Kinburn, Ontario.*

Small drainage systems are readily identified in the air photograph. The tile drainage (Position 1) leads into a single diagonal drain emptying into the road ditch which runs through a road viaduct (Position 2), drains away in field ditch (Position 3) and finally into a gully (Position 4). Note that the tile drainage is clearly visible during May, less discernible in June and obliterated in July due to heavy vegetative cover except where the livestock has kept the cover short in the rotation pasture. The grain field (Position 5) has a very uncommon pattern caused by mechanical failure of the seed drill. Such irregularities require further ground checks. The outcrop in the bottom of the photos could be more readily identified if a larger mosaic of this area was used. Actual rock outcrops (Ro.) The farmers whose fields are adjoining this outcrop will often have drainage difficulties as the drainage from the impervious outcrop has excessive run-off qualities. Note the deciduous tree growth on the clay loam and scrub growth of the outcrop area. Note the typical binder-cut pattern of the grain.

Most of Canada has been subjected to continental or alpine glaciation. The glacial land forms are regularly associated with and influenced by the underlying and outcropping bedrocks.

The underlying bedrocks are divided into three main groups: igneous, sedimentary and metamorphic.

The igneous rocks such as granites are formed by the intrusive flow of molten materials within the earth and the basalts and other lavas formed by the extrusive flow. They are subject to jointing and faulting.

The sedimentary rocks such as sandstone (separate grains of quartz and other minerals cemented by such agents as oxides of iron, calcium carbonate, clay and sometimes silica), shales (consolidation of clay and silt) and limestone (consolidation of calcareous deposits) are formed from the sediments of other rocks and were deposited and compressed under water. They are found in horizontal or tilted positions.

The metamorphic rocks such as schist, gneiss, slates, quartzite, etc. are formed by diastrophic heating and pressurizing of the igneous and sedimentary rocks. They are generally found in folded positions.

Glacial drift includes all the material deposited by glaciers even though they may be subsequently modified by wind or water.

LAND FORMS.—A land form may be conceived as a distinctive three-dimensional landscape resulting from the synthetic effects of all geologic materials and processes in its formation and environment. In addition to being formed by a particular geologic process, ordinarily land forms have a characteristic configuration or topographic form and a characteristic structure and range of materials. For example: Outwash plains, eskers, alluvial terraces, active flood plains, etc. Commonly, only a portion of a land form may be seen in a single aerial photograph or in a strereopair. Following is a discussion of some common land forms associated with continental glaciation.

Glacial Land Forms.—Till is glacial drift that has been released by the melting of the ice, without subsequent movement by wind or water. It is largely made up of mechanically broken fragments of the nearby bedrocks. Such fragments may range from the finest clay to immense boulders.

Till is found as moraines and drumlins. Moraines are designated by their position with relation to the ice sheet as terminal or end, recessional, interlobate and ground moraines or may be designated according to their materials such as till moraines and kame moraines.

A terminal or end moraine is one formed at the outermost stand of any marked advance of a glacier. Terminal moraines vary from simple smooth ridges to the most complex aggregation of knobs and ridges with enclosed kettles or pits. Recessional moraines are end moraines deposited where the ice border was stationary for a short period during the general retreat of a lobe. Interlobate moraines are formed in the angle between the margins of two lobes. Such moraines contain many kames and much outwash. A ground moraine is a mantle of glacial material over an area formerly occupied by ice. Where the mantle is thin, the topography may be controlled by the former land surface, whether bedrock or earlier glacial deposits. Thick deposits tend to form till plains that may be drumlinized, fluted or undrumlinized.

A drumlin is a smooth oval hill which has its long axis parallel to the direction of the glacial movement. It is composed of materials which are generally the same as the adjacent glacial deposits.

Glacio-Fluvial Land Forms..—Kames are constructed of water-laid sediments laid down at or close to the margin of the ice where melting was at its maximum. They occur largely as isolated conical hills or ridges and in masses within or closely associated with the till.

Outwash plains are formed by melt-waters of the glacier flooding moraines and other land forms. They vary from narrow fillings in the bottoms of pre-existing valleys to coalescing alluvial fans. The long and narrow deposits are called valley trains. Some extend for many miles from the ice front whence they originated. The individual units of coalescing alluvial fans commence at breaks or low spots in the terminal moraines. The texture of the sediments varies from coarse near the source to fine at the outer fringe. However, since deposition may continue for a considerable time, depending on the relative movement of the ice with respect to the source of the outwash, coarse materials may be overlain by fine materials or in reverse order. The outwash plain may be unpitted or pitted. Unpitted outwash plains show remnants of channels that are now abandoned and partially filled by wind-drifted materials. These channels have local differences in texture where the natural levees were formed by flood water. Pitted outwash contains kettles that vary in size from a few feet to miles across. They vary in shape from circular to irregular and their depth varies considerably. At times the kettles are long and narrow and are arranged in rows called kettle chains. Pitted outwash plains commonly have a level skyline as distinguished from the irregular one of a moraine.

Many outwash plains and valley trains consist of steps or terraces formed by stream erosion. Often there is a flood plain along the watercourse, not uncommonly associated with a set of terraces at different levels, which roughly parallel the existing drainage. In other places, no modern stream or flood plain is present. Eroded valleys with tributaries and wide flat floors are present in many outwash and other glaciated areas where the present stream appears too small to have accomplished the erosion.

An esker is a single crooked, irregular-crested ridge, or a series of such ridges which extend in the direction of glacial movement. The ridges may branch and re-unite, locally enclosing undrained depressions. It is the deposit of a stream in a tunnel or channel in the ice and is therefore generally made up of gravels and sands. The material in eskers varies over a wide range of particle sizes; the eskers themselves are superimposed on all kinds of surfaces including ground moraines, outwash, deltas and drumlins.

A crevasse filling is a single level-topped ridge which extends in the direction of a former crevasse in the ice. It was deposited by a stream in an open crack of the ice. The materials are predominantly sands and gravels. Crevasse fillings occur in pitted outwash, pitted lake terraces or deltas, drumlins and moraines. In pitted outwash, they project into a kettle, from the margin of a kettle or make the division between two adjacent kettles. One or both ends of the crevasse filling join the outwash plain with accordant level.

Glacio-Lacustrine Land Forms.—Lacustrine or lake basin topography is generally the most level of all land forms. However, some lakes covered pre-existing glacial forms and tended to modify these both by erosion and deposition. Some lake basins covered by sand have the materials wind-worked to an uneven topography, including dunes. Other basins, because of their position and their large proportion of impervious materials, are greatly dissected. The

impervious materials are generally silts and clays that have settled in the deeper parts of the lake. Shorecliffs and cut terraces are erosional features of glacial lakes that were cut by the waves attacking the pre-existing slope. In rock, the cliff may be vertical, overhanging or cut into caves. In drift, the slope slumps to the angle of repose for the material involved. The cut terrace is the submerged terrace or pavement below the shorecliff. The debris worn from the cliff and dropped by the undertow at the outer edge of the cut terrace forms a "built terrace" of sand and gravel which dips toward deep water. Usually associated with lacustrine deposits are old shoreline beaches composed of sands and gravels. They were formed by wave action and were heaped up into smooth horizontal ridges paralleling the original shoreline. Bars, spits and hooks are other wave-formed depositional features. Deltas are formed by the deposits of streams entering a lake from the land or from a tunnel or crevasse in the ice. As deposition in standing water is sudden, the material which will not stay in suspension when deposited forms layers at the angle of repose for wet sand (about 25 degrees). Land streams add successive layers at the angle to form a submerged half cone which is built out into the lake. Shifting of the stream from side to side causes the layers to be spread more or less uniformly around the side of the delta until its apex reaches the surface of the lake. A stream whose course is lengthened by formation of a delta has its gradient decreased and deposits more material. Adjoining deltas coalesce. These and outwash plains have similar topography. The materials range from sands and gravels to silts and clays.

Muck and Peat.—Muck and peat are largely associated with poorly drained areas. The materials are formed in depressions already existing and filled with water. The gradual filling in by vegetation growing in and along the edge of the lake or channel creates the muck and peat. They may be found in various stages of development, and in the agricultural areas of Canada the original outline is clearly shown. The peat materials consist of a fibrous mass in which leaves, bark and fragments of limbs and twigs can be identified. In muck these have reached a stage of decay and the fibrous materials are not recognizable.

Weathering.—Weathering of the soil involves physical and chemical changes such as oxidation, reduction, hydration, leaching and the chemical decomposition of complex minerals. When the weathering has progressed a long time, the soil profile establishes distinct horizons. Climate, vegetation, topographical control of the percolating waters, etc., all have an important bearing on the type of profile developed.

Drainage.—Although, by itself, drainage cannot be relied upon to identify the land forms and soil textures without further identifying characteristics, it is one of the most important factors to be considered.

Straight drainage may infer either bedrock structural alignment or evidence of a steep gradient. Where there is no structural alignment the drainage will be curved. In coarse-textured soils each stream or tributary is usually farther apart than in the finer-textured soils.

Streams are designated as young or mature depending on their age. The mature stream is one that is able to maintain an equilibrium by eroding or depositing, always maintaining a balance, such as a flood-plain stream. A young stream is one that has sufficient speed and volume to carry its sedimentary load and at the same time be able to erode its channel.

Generally, the ground slopes, when considering the micro-relief of an area, are steepest when the materials are granular and semi-granular and soft or smooth when the materials are predominantly clay.

There are many known types of drainage patterns that are affected by the soils and bedrocks. The interpreter will probably establish patterns and combinations of these patterns as experience is gained. The following are some of the basic drainage patterns.

Dendritic. The pattern forms the shape of the branches of a tree. The drainage has a free movement and is not directed by the structure of the bedrock.

Trellis. The shape of a vine or garden trellis. The main tributaries are long, straight and parallel to the main stream, with comparatively short secondary tributaries and joined to the main tributaries at right angles. This pattern is found in an area of folded or faulted rocks.

Radial. The shape of the spokes of a wheel. Such streams are either flowing from an isolated hill or towards a basin.

Parallel. This pattern is the shape of a broom or horse's tail generally denoting a pronounced slope.

Anastomic. This is a flood-plain type of drainage with a meandering stream, old channels, oxbow lakes, and sloughs. If found within an extensive plain or lake bed it may be considered the forerunner in the development of dendritic drainage.

Dichotomic. This drainage pattern has the shape of a hand-held fan and may be very large or small depending on the size of the alluvial fan or delta having a distributary system.

Rectilinear. Man-made ditches that usually follow topographical control lines such as section or concession lines. They are not a true evolution of drainage and are not to be confused with a distributary irrigation system.

Tile Drainage. This system is usually identified by the comparatively dry soil over the tile or by the differential vegetative growth between the tile.

Kettle Holes. These are random depressions with the occasional water-filled basin such as those found within the more granular moraines and outwash plains. The depressions have their own drainage systems. The soils found within the depressions may be a collection of humus that is partially restricting the drainage, or the result of the finer materials eroding into the depressions. Vegetative cover will aid in determining whether the soil is deep enough to restrict the drainage long enough for cultivation purposes.

EROSION.—Gullying, sheet and wind erosion are the predominant types. As the gullies cut through an area they are controlled by the cohesive qualities of the various soils. Silts and sandy clays have "U" shaped gullies. A broad, rounded gully is generally associated with a deep plastic or clay soil. Granular materials have "V" shaped gullies. Very broad and shallow "V" shaped gullies are found when the silty or fine sandy materials are over shallow bedrock or an impervious subsoil. The shape of the gully is not always consistent with the soil texture, thus other associated features must be identified. Sheet erosion occurs when undesirable cultural practices have allowed a slope to become susceptible to erosion.

Wind erosion is generally found on sandy soils in an arid area. Sand dunes are unmistakably recognized by their crescent shapes, their directional trend with the wind and the heavier vegetation growing on the protected side. Sand dunes are commonly associated with marshy

lands. Other wind-worked areas have a honeycomb pattern due to differential trends of the wind. The dunes and wind-worked sandy areas, except for the marshes, have a well-drained appearance. Blowouts are found mostly in the sandy areas and are recognized by their light, generally white, tones where there is little or no vegetation. Occasionally, the established blowout contains a slough, but the position of the blowout and its comparatively poor vegetation belie a true slough or basin. A cultivated field being wind-worked has the appearance of having been moved, by the identification of the very light smooth encroaching cover over the adjacent field or area. Fences that have collected the drifting material are generally recognized by their fullness. However, the drifting is not readily apparent in the photos and the interpreter would have to deduce whether certain well-drained soils would drift under cultivation.

General.—The over-all color tone of soil is locally affected by the drainage and water table as well as the varying colors of the cover; thus, the color tones are closely related to drainage and soil texture. The lighter tones in the photograph may be considered as an indication of more pervious-textured soils and the darker areas of more impervious soils. For instance, within an area consisting of predominantly clayey soils, the lighter areas may be due to the better drained silty or sandy areas. Where there is a pervious soil over an impervious subsoil and the water table is high, the tone becomes darker and may be confused with an area of more plastic soils. It can be seen that other identifying features have to be brought into play when using tone as a texture identifier.

The drainage and water table have, perhaps, the greatest influence on vegetation changes in any climate; thus the identification of vegetation should enable the interpreter to separate the well-drained from the comparatively poorly drained soils. Although the interpreter may not be an expert in forest identification, he can however with good ground checking develop a working knowledge of the kind of forest cover.

Cultural practices give some indication of soil texture. For instance, parallel, plowed, drainage furrows or "dead furrows" are usually associated with plastic, poorly drained soils; contour plowing, strip cropping, terracing, etc., show a friable soil open to wind or water erosion, generally over an impervious subsoil.

A workable knowledge and the practical application of the elementary principles outlined above, plus the inevitable ground check, and the actual furthering ability of the aerial photographic interpreter himself, will supply the details for a closer photographic identification of the soils.

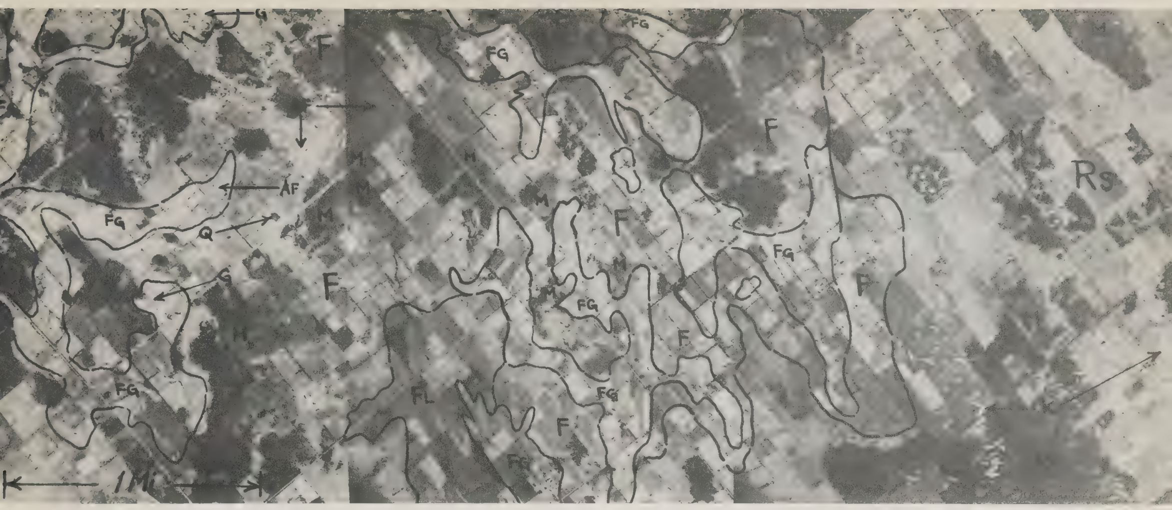

FIGURE 12.—*Mosaic photographed July 25, 1946 of a limestone bedrock and beach influenced area located in the vicinity of Richmond, Ontario*

Gravelly and shingly sandy loam beach ridges formed by the Champlain Sea (FG). Note the light, well-drained appearance—especially in the more gravelly areas. Gravel pits (G). Undifferentiated shallow soils over limestone (F). Limestone quarry now filled with water (Q). Stereovision would immediately spot this comparatively level and deeper loam area (FL). The high water table does not alter the uniform loam pattern (note the same water table tone to the right in the sandy area). Abandoned farms recognized by the lack of activity around the buildings and the even grass and hay growth of the unworked fields (AF). Water-and-wind-worked sands over level impervious clays (RS). Wind-worked knolls (K). Muck areas that have been ponded by the bedrock or found in association with sands (M).

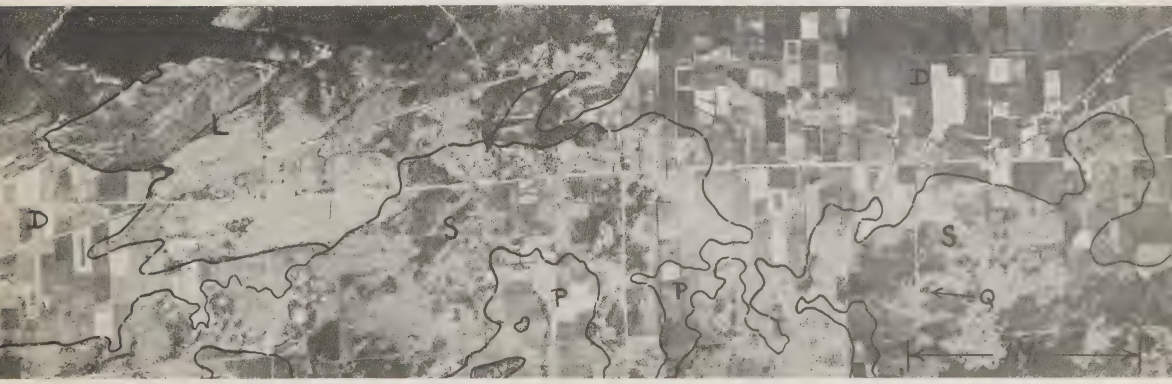

FIGURE 13.—*Mosaic photographed June 30, 1952, of a limestone and sandstone bedrock influenced area located in the vicinity of Constance Lake, Ontario.*

Shallow soils over limestone (L). Shallow soils over sandstone (S). Stereovision would show the smoother appearance of the limestone in comparison to the abrupt appearance of the sandstone. In the limestone, cedars are found where the soils are shallow and maples where the soils are a little deeper. In the sandstone, pine, birch and aspen are found. Both areas consist almost entirely of rough pastures, with their stumps, rocks and outcrops. Sandstone quarry filled with water (Q). Pockets of clay soils that were left by the marine waters (P). Deeper water-laid clay soils that were left by the marine waters (P). Deeper water-laid clay soils that have been influenced by pre-Ottawa channelling (D). Muck vegetation (M).

FIGURE 14.—*Mosaic photographed June 30, 1952 of deep-water laid soils that have been influenced by pre-Ottawa River channelling located in the vicinity of Constance Lake, Ontario.*

Two water-worked directions are noticeable; the right-angled direction of the deltaic sands in the lower left to the curved ridging of the silts and clays arcing from left to right. The ridges were probably formed by the slowly receding channel waters. The inter-ridge areas have been eroded by the "directed" modern drainage. The streams flowing through the clays towards the ridges are somewhat parallel denoting a uniform slight gradient in this area; a more poorly drained portion of the clay area (PD). Note the extreme variation in growth of the hays, grains and heavier vegetation. Sands approximately 3′ to 4′ deep (RS). Note the stream meandering back through the sands and underlying impervious materials. Sandy loam over clay (MSL), surface sands and poor gravels on the slopes of an old channel (P), deep clays with the surface silty and sandy influence (RC), surface sands with the sandy vegetation and sandy gullying (S2). Note the intrusion of the shrubs and trees into the adjacent pasture and hay fields. The stream disappears into the small sandy fan (S3). Wispy appearance of surface sands (S4). Muck and sands (M & S). Note the even sedge vegetation of the muck areas. Summer resort (RE). Trees and brush have been cleared probably to make way for new cottages (B). Rock outcrop (O). Note the forward tilt (aircraft flying towards left) due to poor camera or flying operations. This can be seen at the outer left edges of the individual photos.

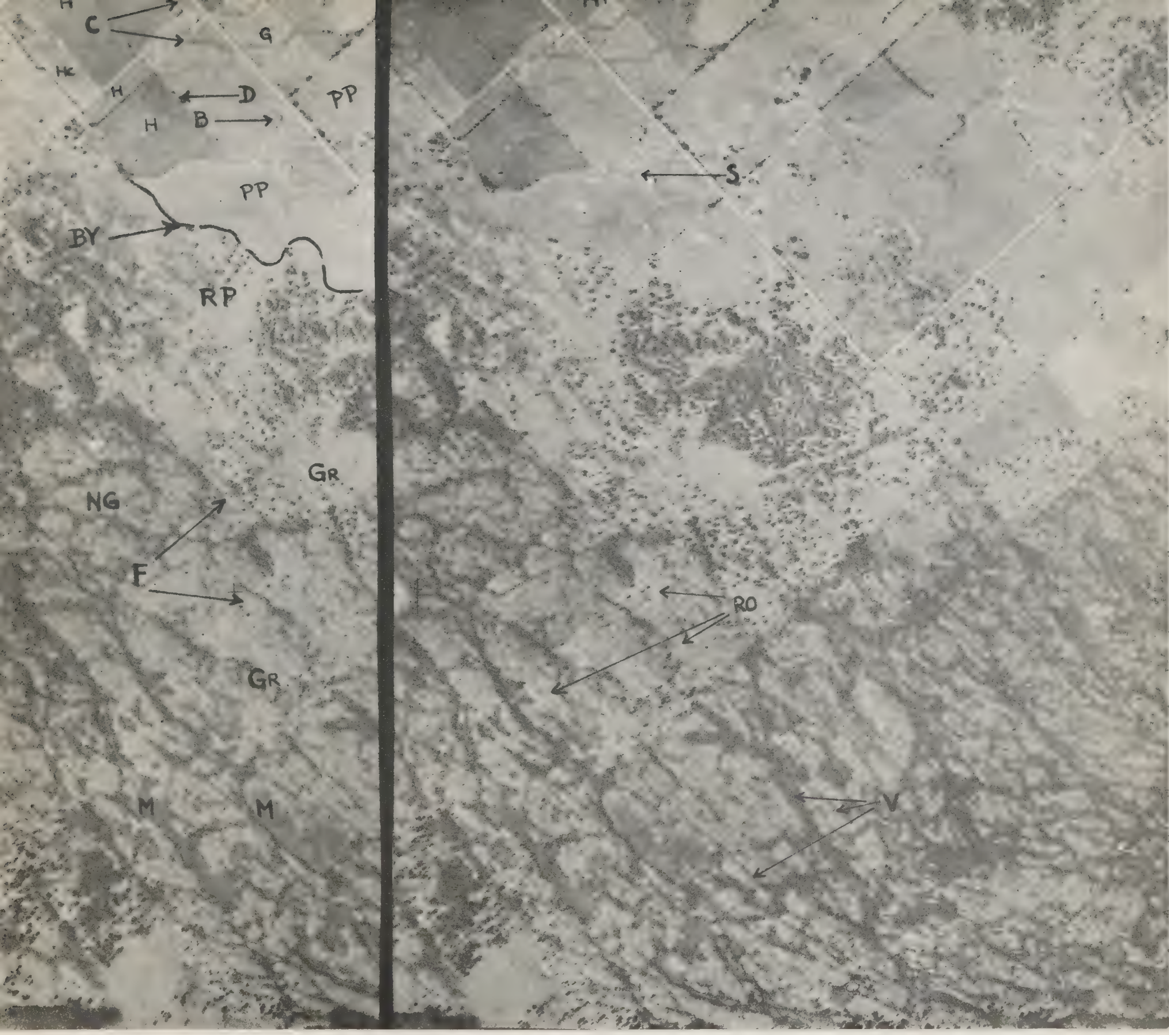

FIGURE 15.—*Stereopair photographed July 18, 1946, of a pre-Cambrian outcrop and rock-knob area located in the vicinity of Dunrobin, Ontario.*

The "squeezed" curved gneiss pattern can be seen. The original sands of this area were washed off by the marine water. The upper part of the photo shows a plain of water-laid clays and silts through which project occasional bedrock outcrops. In the area of extensive bedrock outcrop in the lower part of the photos, the deepest soils are found in the small parallel valleys that were presumably formed by chemical erosion followed by ice channelling. The heavier scrub vegetation grows in these soils and aids in the alignment recognition. Actual rock outcroppings (RO). Numerous muck areas that have been ponded by the bedrock (M). Clay field gullies of the deeper soils (C). Note the silty influence found in the lighter fringes of the gullies. Man-made field boundary drainage flowing diagonally to the small stream (D). White areas due to cattle scuffing of the stream banks or where stream has attacked the banks especially where the soils are shallow over the bedrock (S). Note that the stream is directed by the bedrock. Boundary (BY) between improved pasture (PP) and rough pasture (RP). Buildings no longer in use (B), in poor shape even for storage purposes. Fence (F) between the grazed area (GR) and the non-grazed area (NG). Darker tone of non-grazed area due to the smaller scrub and grasses that have been allowed to grow. Hydro pylon (HY).

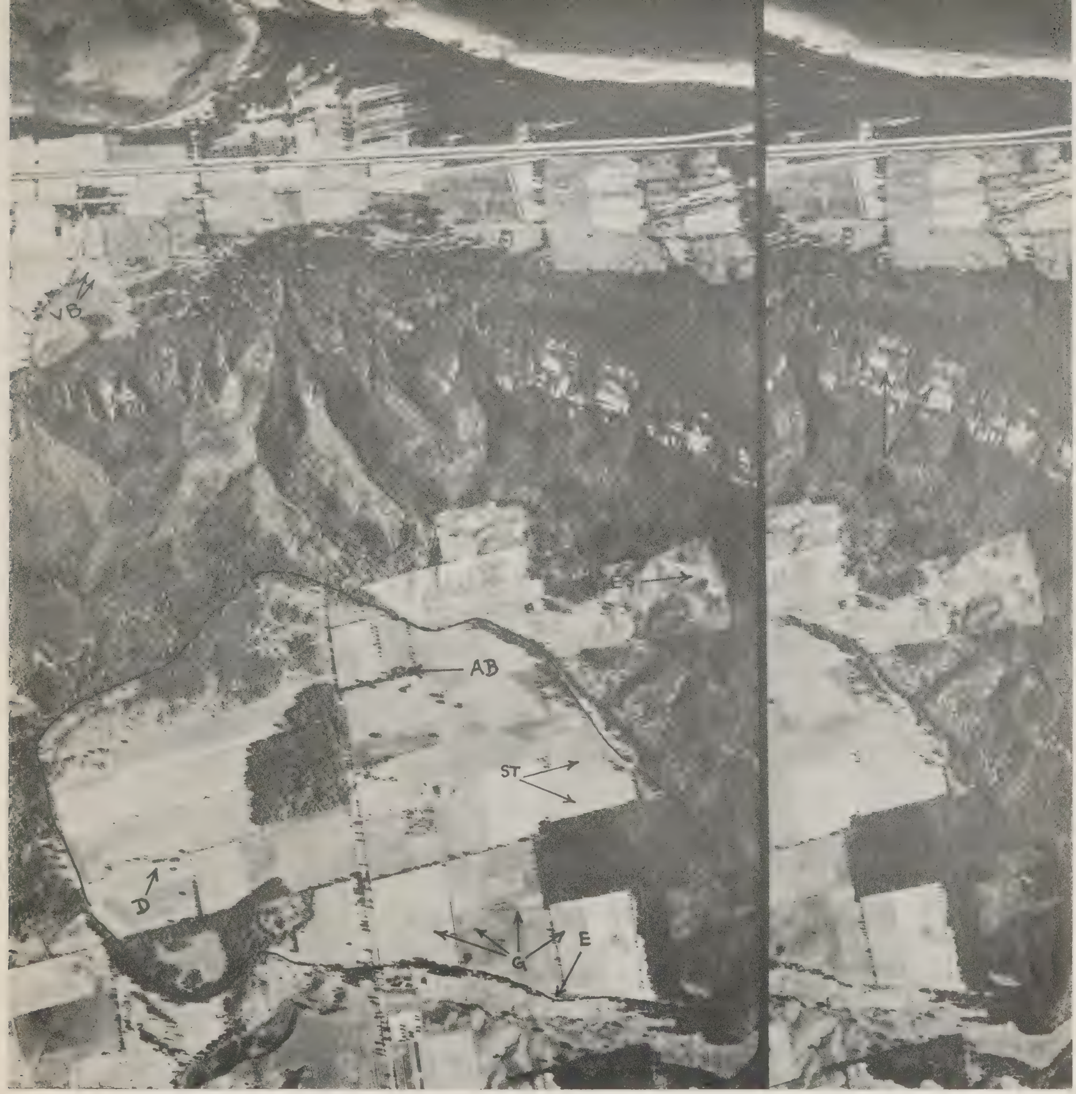

FIGURE 16.—*Stereopair, photographed August 5, 1938, illustrating the erosion of different horizontal bedrocks of the Niagara escarpment in the vicinity of Thornbury, Ontario.*

The enclosed area is a cap rock of dolomite. It is more resistant to weathering and erosion than the underlying shale. Chunks of rock and debris are falling away where the shale is eroding an "undermining" gully (E). The silty clay loam till of the cap rock area partially restricts the drainage as can be seen by the ditch (D), dead furrows and slight gullying (G). However, the vertical jointing of the dolomite allows moderate internal drainage. Severe erosion of the clays on the outcropping shale (ES). Note the terrace effect due to a more resistant bedrock at the base of the shale cliff. This rock has been affected by previous beach and shorecliff activity. The clays eroded from the shale cliff have been deposited lower down on the cliff slope and on beach sands below the cliff. Bands of vegetation (VB) due to thin layers of more resistant bedrock. Note the angle at which the waves attack the present shore. The shoreline (left of photo) and the sandy hook, trends to the northwest. Stone piles (SP) and an abandoned farmhouse (AB).

FIGURE 17.—*Stereopair photographed May 6, 1930 illustrating part of a clay till moraine with silty surface soils, in the vicinity of Lucknow, Ontario.*

A tributary system, with its field gullying, entering into the main stream is shown. Alluvial fans (F) have been deposited (probably upon low outwash terraces) in the spillway or outwash valley, by the streams and gullies of the moraine. The outwash waters cut a terrace in the moraine to the south, mixing outwash materials with the till (T). Some kettles have become part of the present drainage pattern. Severe gullying, especially with steeper areas, suggests conservation practices might well be introduced such as the use of cover crops and contour plowing.

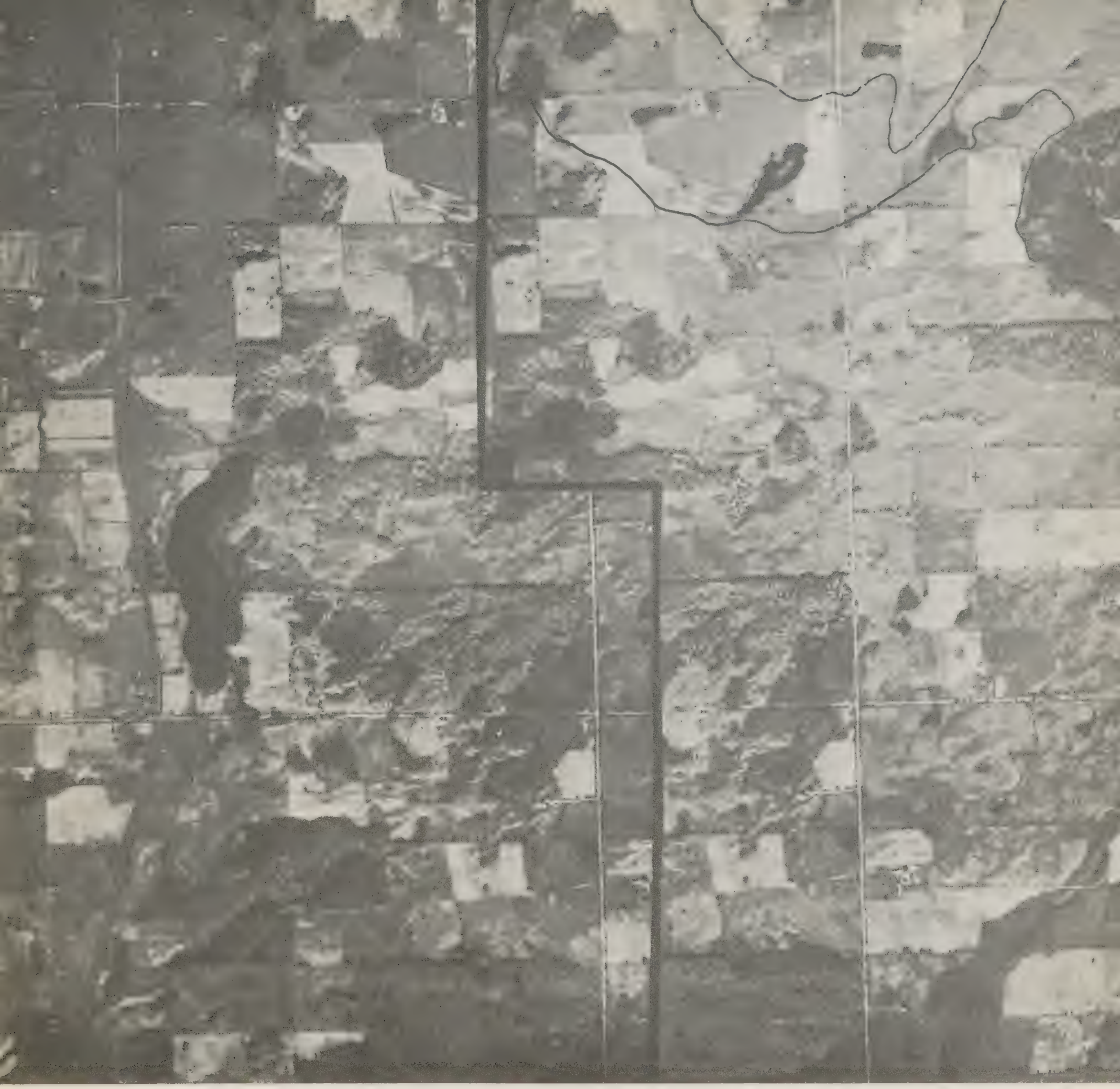

FIGURE 18.—*Stereopair photographed May 8, 1930, illustrating part of a kame moraine near Lucknow, Ontario.*

The conical, well-drained kames and other stony till and knob and kettle topography are readily recognized. Several local gravel pits can be seen in some of the kames. An area of well-sorted outwash, with the occasional kettle is enclosed in the upper part of the photos. Many stone piles can be seen. Note the contrast between the deciduous growth of the well-drained soils in comparison to the cedars, and occasional deciduous and predominant sedge vegetation of the muck areas. Several apple orchards can be seen. It is a general farming area with grains, hays and pastures forming the most common crops. The steep slopes are in grass or forest cover in the well-drained sandy loam areas.

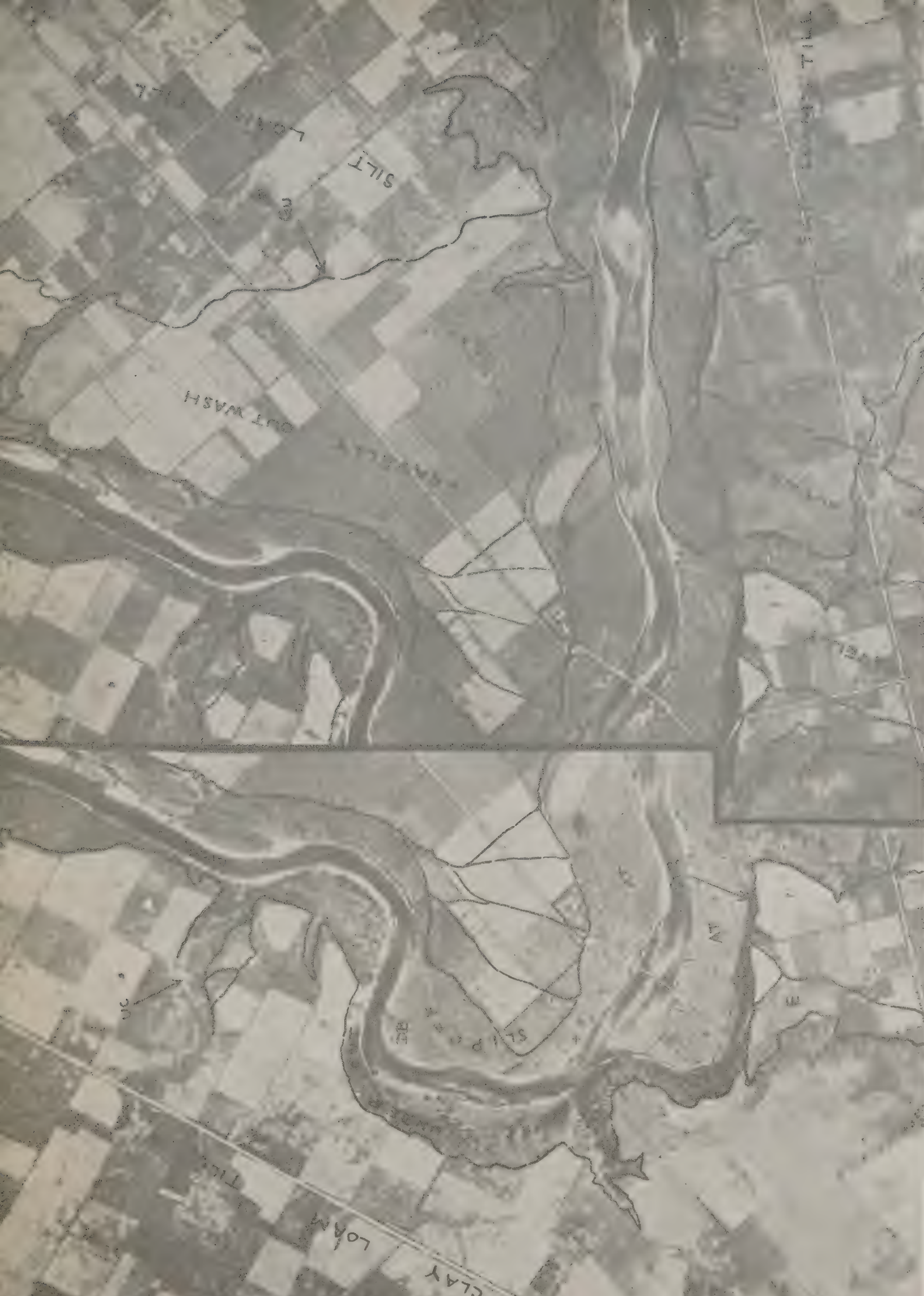

FIGURE 19.—*Stereopair photographed May 8, 1930, illustrating well-sorted gravelly outwash terraces located in the vicinity of Holmesville, Ontario.*

Many stream-cut terraces are apparent. The drainage from a gully (GU) disappears into gravelly materials where the outwash is adjacent to the moraine. The stream (STR) cutting through the outwash terrace and flowing at the junction of the undercut slope and the alluvial terrace, maintains the course previously cut by the river. Debris (DB) of boulders, etc., that have eroded from the undercut slope into the river. The undercut slope (UC) in the gully contains outwash materials through which the small stream is cutting. Local fine materials (E) that have eroded on to the terrace. Note the more severe gullying in the clay loam moraine to the west in comparison to the silt loam moraine to the east. Recent alluvial terraces (AT).

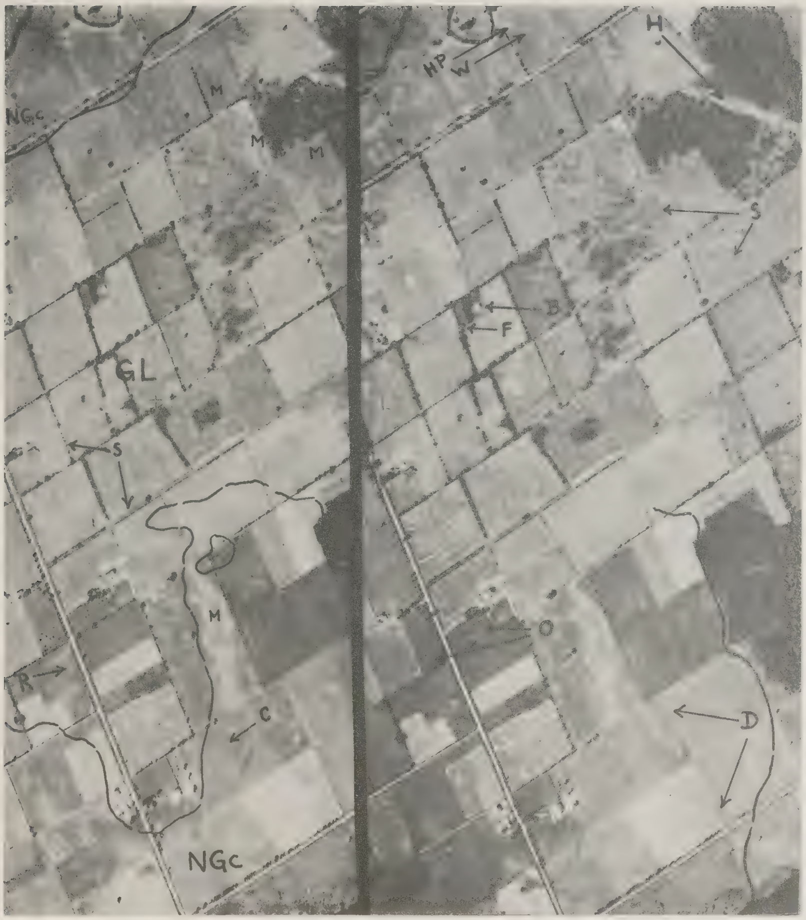

FIGURE 20.—*Stereopair photographed August 18, 1946 of a drumlinized till plain that has been modified by receding marine waters in the vicinity of Metcalfe, Ontario.*

This area has the characteristic relief of a drumlinized till plain of the St. Lawrence Lowland area. Although the hills appear to be at random the drumlinoid effect is still apparent, especially when viewed in a large mosaic. The region was modified by receding marine waters as can be seen by the strand ridge (R). A "borrow pit" may be seen in the ridge. The lower and more level area (NGc) of deeper soils has been influenced by the mixing of the finer materials of deep-water deposits and the till materials of the adjacent higher area. The numerous "dead furrows" and other artificial drainage patterns indicate a more impervious clay loam soil. Stone fences found only in the till area (S). The occasional stone pile and dump is present. Muck areas (M). Cattle in a rotation pasture (C). Apple orchards found in a well-drained loam (C). The till area shows hay fields, pastures, the occasional truck crop and farm gardens. The clay loam area has the better hay and grain crops and pastures. Abandoned farm house (F). Barn now used for crop storage (B). Hydro pylon (HP). Hydro wires that can be seen by their reflection (W). Hydro right-of-way through the heavier vegetation (H).

FIGURE 21.—*Stereopair photographed July 25, 1946 of drumlins on a till plain that has been modified by marine waters. Located in the vicinity of North Gower, Ontario.*

Drumlins (D). The paved highway follows the "in-line" drumlins. Till or boulder ridge formed to the steep side of the drumlin (R). Junction between "Z" fence and stone fence (J). "Z" fences on the deeper soils between the higher areas (Z). This area is comparatively stone-free. Lacustrine loam (OL). Deeper water-laid clay loam (NGc). Notice the high water table in these areas. However, the area north of the stream has a slightly lighter appearance due to the influence of the silty and sandy materials in higher topographic positions. The area to the south of the stream contains more clay. Man-made drainage follows field boundaries wherever possible (DR). Meander scars made by the stream (A). These scars are higher than the present level of the stream. Cattle and other livestock have scuffed the clay soils where they have passed between the adjacent hay field and the stream bank in the permanent pasture area (CE). Cattle in an improved pasture (CA). Small bridge crossing a drainage ditch (B). Note the cattle trails through the pasture fields and the mowing and raking activity in the hay fields.

FIGURE 22.—*Stereopair photographed August 25, 1938, illustrating part of a fluted till plain and an esker, located in the vicinity of Mt. Forest, Ontario.*

The poorer drainage of the lower fluted areas tends to give the area a drumlinoid pattern. A rather "true-type" esker can be seen in the upper right of the photos running parallel to the flutings or the direction of ice movement. Note that the esker lies in the lower muck areas. The water table in the area is high. The smooth topography does not facilitate good internal drainage. Drainage ditches, dead furrows and the muck areas are apparent. The occasional silty gullying in the silt loam area is recognizable. The stream in the lower right wanders through the plain. Abandoned buildings and old cellars can be identified.

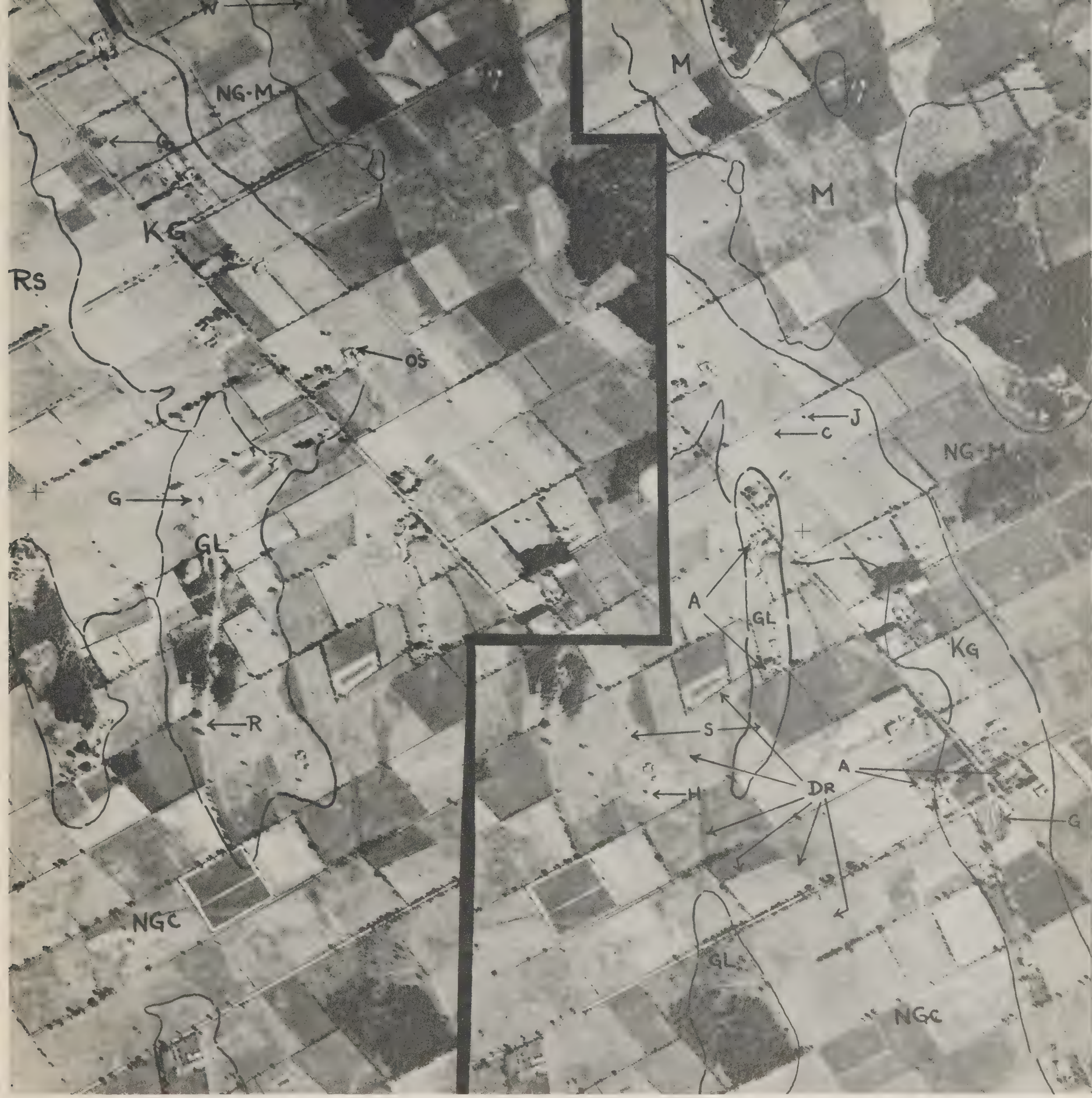

FIGURE 23.—*Stereopair, photographed July 25, 1946, showing an esker and drumlins that have been modified by receding marine waters in the vicinity of Kars, Ontario.*

Esker composed of gravelly sandy loam (KG). Note the very light grey tone of the esker indicating a very well-drained soil. Gravel pits (G). Drumlins and other till loam (GL). A till or boulder ridge (R) that was formed by the receding sea may be found on the steeper side of this drumlin. Sandy soils that were evidently washed from the adjacent esker (RS). Clay loam consisting of materials from the adjacent high areas and mixed with the sea materials (NGC). Notice the man-made and "dead-furrow" drainage of this area with its high water table. Water hole (W) denoting the impervious, deep water-laid clays. Clay loam-muck phase (NG-M). Notice the level appearance of the muck and the occasional muck vegetation. Junction (J) between "Z" fence and a stone fence. Stone fence (S). Small apple orchards found on the well-drained soils (A). Cattle (C). Open silo (OS). The occasional field of corn and potatoes can be seen on the well-drained areas with the hays and rough pastures predominating. The better hays appear to be growing in the clay loam areas. Cellar of a demolished house (H). Notice the mowing and raking activity in the hay fields. Note the man-made drainage (DR).

FIGURE 24.—*Stereopair photographed June 13, 1938, illustrating morainic ridges in the vicinity of Tara, Ontario.*

Note the morainic ridges at right angles to the drumlin. The drumlins are formed in the direction of ice movement. The inter areas consist of ground moraine. A sinuous esker (E) runs in the general direction of the ice movement. Note the ridges or strands to the east side of the drumlin and the absence of stone piles in the lacustrine areas in contrast to the till areas.

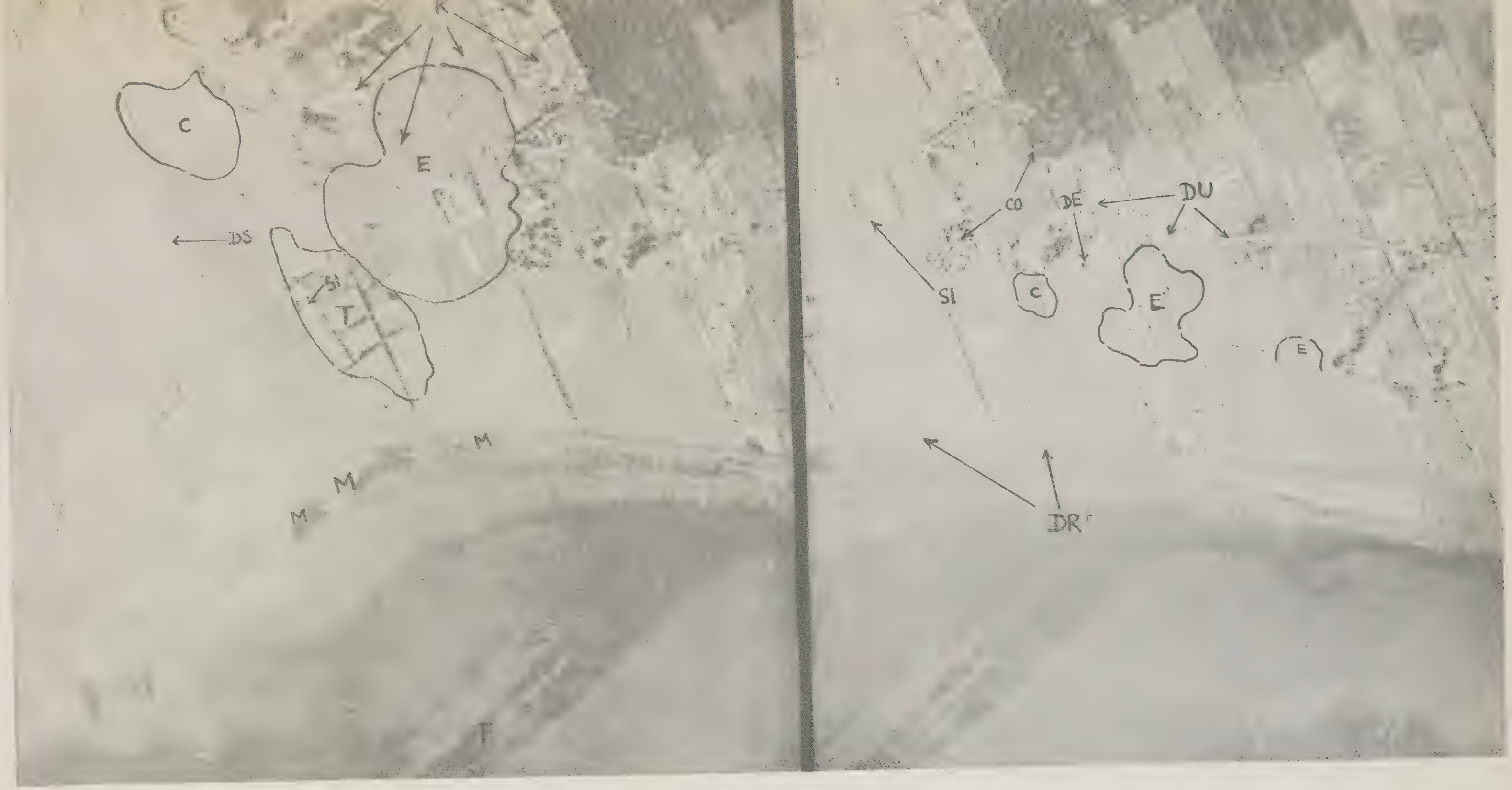

FIGURE 25.—*Stereopair photographed August 18, 1946, of deltaic sands that have been influenced by pre-Ottawa River channelling in the vicinity of Blackburn, Ontario.*

The modified bluff running across the center of the photos was cut by the pre-Ottawa River. Note the Soil-slide (E). The soils on the lower area appear to have been eroded from the upper "bay" area. Alluvial cones (C). Drainage (DS) from the alluvial cone wandering through the sands and silts and eventually caught by the man-made systems emptying into the peat bog. An area of till (T). Open double silos (SI) adjacent to the barn. Note the corn fields on the small cone. Sandy knolls (K). Man-made drainage under a paved road (DU) and under a railway (DR). Small fields of the truck farms can be seen in association with the deeper sands. General farming takes over on the lower area, which is a sandy loam and may be recognized by the lighter, wispy, water-worked sands and silts over clay. Fire pattern in slightly decomposed fibrous peat materials (F). Occasional muck vegetation at the edge of the bog (M). Coniferous vegetation (CO). Deciduous vegetation (DE). Note the differential growth due to cutting in the heavier wooded areas.

FIGURE 26.—*Stereopair photographed May 14, 1947, of deltaic fine sands and silts over deep water-laid clays in the vicinity of Edwards, Ontario.*

Above the broken line is a transitional area between deeper sands, and the silts and fine sands below the line. Note the wispy and dusky appearance of the fine sands and silts in combination with the very high water table. The relatively level impervious clay is approximately two feet below the surface; thus the entire area consists of dead furrows and man-made drainage systems (D). When photographed, the area was saturated as can be seen by the sun-reflected sheen areas (S). Note the better-drained areas adjacent to the natural drainage systems. Note the old aerodrome which is now under cultivation and the directional aircraft markings still visible. Areas of native vegetation that include forest cover of maple, birch, pine and spruce (NV). Brush clearing operations (B). Sandy knolls (K).

FIGURE 27.—*Stereopair photographed May 14, 1947 of a large esker that has been modified by marine waters in the vicinity of Gloucester Station, Ontario.*

The sands and gravels have a well-drained appearance. The darker tones in the deepest sands (US) are due to the poor hays and grasses. Blowouts (BO). Note the drifting soils invading the adjacent hay field (DS). Gravelly sandy loam (KG). Beach or strand ridges made by the receding marine waters (R). Gravel pits (G). Reforested pine (RE). Pine windbreaks (W). Manured fields (MA). Sands that are not as deep as those adjacent to the west (RS). Scattered shallow sands that are generally poorly drained (GS). Muck and sand (M & S). Note the corresponding vegetation. Surface has been scoured where the muck has been carried away for commercial purposes (MU). The sheen from the surface water in the man-made ditches and dead furrows shows the impervious nature of the underlying deep-water laid materials (OL). The slightly better drained silts and sands of this area were deposited by the activity of the marine waters upon the esker. Note the bar in the lower left.

FIGURE 28.—*Stereopair photographed June 13, 1938, illustrating part of a lake plain and associated features in the vicinity of Clarksburg, Ontario.*

The beach ridges and shorecliff (S) with its pavement, influenced by local erosion of the fine materials from the shorecliff, immediately designate a lake plain. The wide "U" shaped gullies (G) designate well-sorted deltaic sand and silts over the impervious plain. The braided stream (B) was deflected behind the beach and broke through to cut its meanders into the plain. The area consists mostly of apple orchards even on the gravel beaches. The cut terrace or beach pavement is kept in forest, rough pasture and other natural cover. General farming is practised in the remaining areas. Small check dam (D). The forest cover is deciduous. Stream cut terraces (T).

FIGURE 29.—*Stereopair photographed June 2, 1939, illustrating wave-worked beach ribbing in the vicinity of Ripley, Ontario.*

The sandy loam beach with its wave-worked parallel ribbing is apparent. Poor drainage in the areas between the ribs accentuates the pattern. The clay loam till area to the left was under water and the topography was modified by the settling of the lake clays in the lower areas. This area is more poorly drained and gullying is more severe than the comparatively better drained clay loam till area to the right of the beach. Note the field drainage in the area to the west. The lack of stone piles and stone fences is apparent. Surface borrow pits which are no longer in use (SP).

FIGURE 30.—*Single photo, photographed August 7, 1946, showing how poor exposures of a film radically change the over-all tone pattern, located in the vicinity of Richmond, Ontario.*

The dark area found in an arc from the upper right moving clockwise to the lower left is not due to cloud shadows, a high water table, muck soils over clay, heavy clay, etc., but to a faulty exposure of the film. The dark streak will be found in the same position in the corresponding flight photos. This is a lacustrine area with deltaic sands over the clays on the left, loamy silts in the center and clays on the right of the photo. Notice the well-kept track and exhibition grounds in the lower right.

TABLE OF ILLUSTRATIONS

Air Photographs

Ground Stereos

BIBLIOGRAPHY

1. Mollard, J. D. Photo-Interpretation of Transport Soil Materials. *Eng. Inst. of Canada Journal,* June 1941.
2. Mollard, J. D. Aerial Photographic Studies on the Central Saskatchewan Irrigation Project. *Cornell University Library, Ithaca, New York.* 1952. Ph.D. Thesis.
3. Leedy, Daniel L. Aerial Photographs, Their Interpretation and Suggested Uses in Wildlife Management. *Journal of Wildlife Management.* Vol. 12, 1948. pp.191-210.
4. Grant, Fergus, J. Air Photographs, Speed Reconstruction. *Canadian Geographical Journal.* July 1946. p.19.
5. Malhood, Ian. Use of Photographs in Land Appraisal Work in British Columbia. Also, Timberland Appraisal. *Photogrammetric Engineering Journal.* June 1950.
6. Pewnall, L. L. Aerial Photographic Interpretation of Urban Land Use in Madison, Wisconsin. *Photogrammetric Engineering Journal.* June 1950. p.414.
7. Lobeck, A. K. Geomorphology. *McGraw-Hill Book Co., Inc.* 1939.
8. Andrews, G. S. Notes on Interpretation of Vertical Air Photographs. *Forestry Chronicle.* Vol. XVI, No. 3. September 1940. pp.202-15.
9. Sisam, J. W. B. The Use of Aerial Survey in Forestry and Agriculture. *Imperial Forestry Bureau. Oxford, England.* July 1947.
10. Garrad, C. W. An Annotated Bibliography of Aerial Photographic Applications to Forestry. *Syracuse University Bulletin 26, New York State College of Forestry.* 1951.
11. Jenkins, D. S., J. D. Belcher, L. E. Gregg, and K. B. Woods. The Origin Distribution and Airphoto Identifications of United States Soils. *Purdue University Technical Development Report No. 52.* May 1946.
12. Thwaites, F. T. Outline of Glacial Geology. *University of Wisconsin, Ann Arbor, Michigan.* 1950. Sold by author.
13. Frost, R. E. and J. D. Mollard. New Glacial Features Identified by Air Photo in Soil Mapping Program. *Proceed. HRB.* Vol. 26, December, 1947. pp.562-78.
14. Eardley, A. J. Aerial Photographs: Their Use and Interpretation. *Harper and Brothers Publishers. New York.* 1942.
15. The Use of Aircraft in Agriculture in the U.S.A. Published by the *Organization for European Economic Co-operation, Paris, France, Technical Assistance Mission No. 107.* 1953.
16. Lang, A. H., H. S. Bostock and V. O. Fortier. Interim Catalogue of the Geological Survey Collections of Outstanding Air Photographs. *Geological Survey of Canada.* December 1947. p.26-47.

Appendix

Several ground stereoscopic photographs are presented in this appendix to illustrate the actual appearance of the more common crops, soils, etc., on the ground. These reference photos are intended to assist the uninitiated by illustrating the actual subject which he may view on the vertical air photo. Constant reference to these photos will give the interpreter greater confidence in his work. These illustrations refer to definite positions on the previous vertical air photos. The apex of the "V" represents the position from which the ground photo was taken, and the "arms" of the scope of the picture. The figure reference numbers in the following ground photo correspond to the position number on the vertical photos.

FIGURE 31.—*Ground stereo, illustrating recently sown grain (4″), Position 31, Figure 5, May 30, 1952.*

FIGURE 32.—*Ground stereo, illustrating a field of grain (13″), Position 32, Figure 6, June 30, 1952.*

FIGURE 33.—*Ground stereo, illustrating mature grain (24″), Position 33, Figure 7, July 30, 1952.*

FIGURE 34.—*Ground stereo, illustrating a field of oats (4″), Position 34, Figure 5, May 30, 1952.*

FIGURE 35.—*Ground stereo, illustrating a field of oats (15″), Position 35, Figure 6, June 30, 1952.*

FIGURE 36.—*Ground stereo, illustrating a field of oats, Position 36, Figure 7, July 30, 1952.*

FIGURE 37.—*Ground stereo, illustrating a rotation pasture, Position 37, Figure 5, May 30, 1952.*

FIGURE 38.—*Ground stereo, illustrating a rotation pasture, Position 38, Figure 6, June 30, 1952.*

FIGURE 39.—*Ground stereo, illustrating rotation pasture, Position 39, Figure 7, July 30, 1952.*

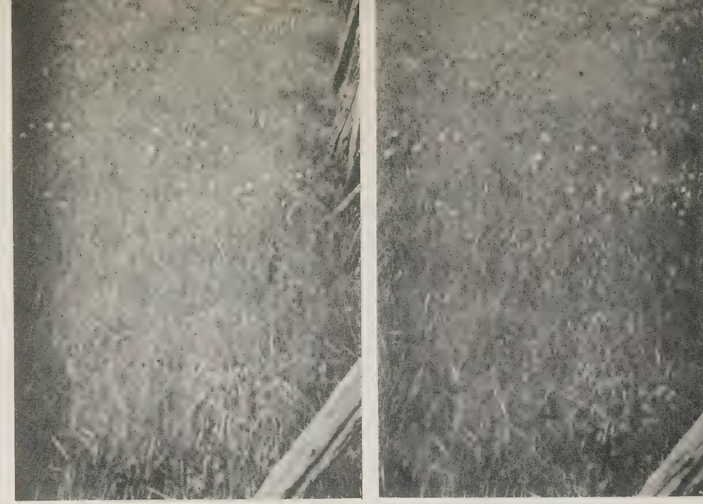

FIGURE 40.—*Ground stereo, illustrating a field of clover and timothy hay (8″), Position 40, Figure 5, May 30, 1952.*

FIGURE 41.—*Ground, stereo illustrating a field of clover and timothy hay (15″), Position 41, Figure 6, June 30, 1952.*

FIGURE 42.—*Ground stereo, illustrating a field of cut clover and timothy hay, Position 42, Figure 7, July 30, 1952.*

FIGURE 43.—*Ground stereo, illustrating a good permanent pasture, Position 43, Figure 5, May 30, 1952.*

FIGURE 44.—*Ground stereo, illustrating a good permanent pasture, Position 44, Figure 6, June 30, 1952.*

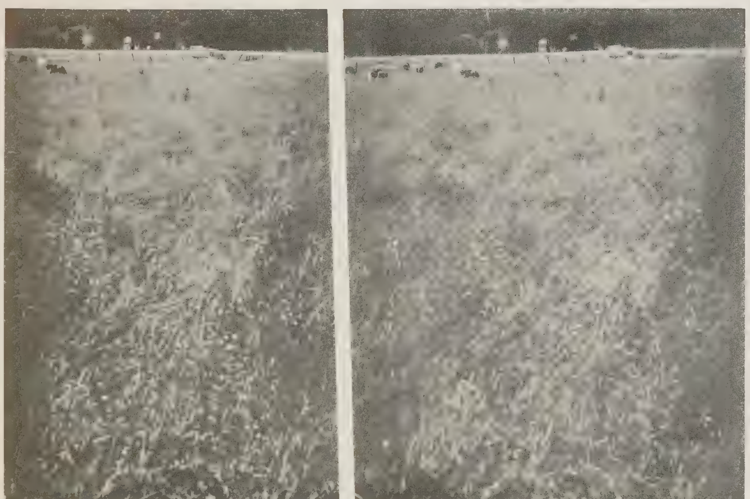

FIGURE 45.—*Ground stereo, illustrating a good permanent pasture, Position 45, Figure 7, July 30, 1952.*

FIGURE 46.—*Ground stereo, illustrating a weedy field (previously grain), Position 46, Figure 5, May 30, 1952.*

FIGURE 47.—*Ground stereo, illustrating a field prepared for seeding, Position 41, Figure 6, June 30, 1952.*

FIGURE 48.—*Ground stereo, illustrating a field of buckwheat in bloom, Position 48, Figure 7, July 30, 1952.*

FIGURE 49.—*Ground stereo, illustrating a new seeding of hay, Position 49, Figure 5, May 30, 1952.*

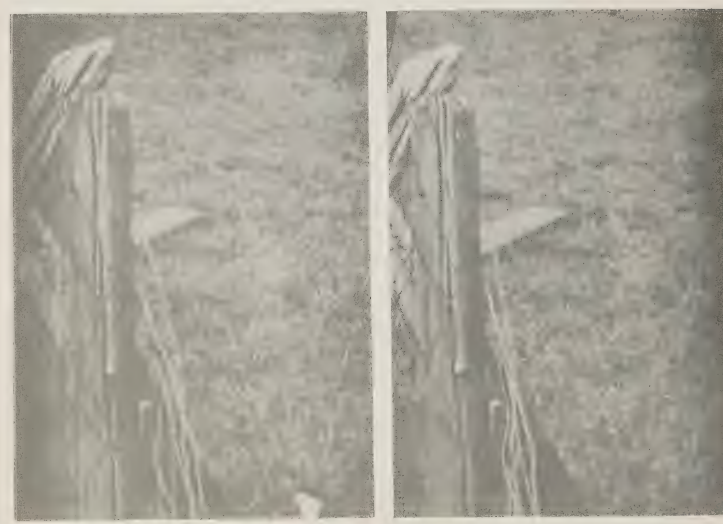

FIGURE 50.—*Ground stereo, illustrating a field of improved pasture, Position 50, Figure 5, May 30, 1952.*

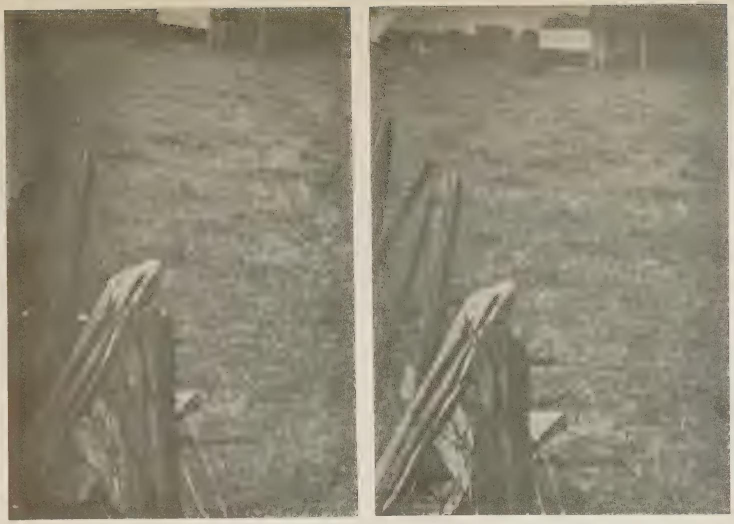

FIGURE 51.—*Ground stereo, illustrating an improved pasture, Position 51, Figure 6, June 30, 1952.*

FIGURE 52.—*Ground stereo, illustrating an improved pasture, Position 52, Figure 7, July 30, 1952.*

FIGURE 53.—*Ground stereo, illustrating the comparison between mixed grain and alfalfa and timothy hay, Position 47, Figure 5, May 30, 1952.*

FIGURE 54.—*Ground stereo, illustrating the comparison between mixed grain and alfalfa hay, Position 54, Figure 6, June 30, 1952.*

FIGURE 55.—*Ground stereo, illustrating the comparison between binder cut, unstooked grain and second growth alfalfa and timothy hay, Position 55, Figure 7, July 30, 1952.*

FIGURE 56.—*Ground stereo, illustrating granitic outcrop, Position 56, Figure 8, May 30, 1952.*

FIGURE 57.—*Ground stereo, illustrating rough pasture in shallow soils, showing weeds, juniper bush, etc., Position 57, Figure 9, June 30, 1952.*

FIGURE 58.—*Ground stereo, illustrating a field of corn, Position 58, Figure 9, June 30, 1952.*

FIGURE 59.—*Ground stereo, illustrating a field of corn, Position 59, Figure 10, July 30, 1952.*

FIGURE 60.—*Ground stereo, illustrating imperfect drainage in a field of grain, Position 60, Figure 3, May 30, 1952.*

FIGURE 61.—*Ground stereo, illustrating rough pasture on shallow soils, with an occasional limestone outcrop, Position 61, Figure 3, May 30, 1952.*

FIGURE 62.—*Ground stereo, illustrating rough pasture on shallow soils, with an occasional limestone outcrop, Position 62, Figure 3, May 30, 1952.*